BBC **WHAT TO DO IF YOU'VE FOUND A METEORITE**

#237 FEBRUARY 2025

Sky at Night

THE UK'S BEST-SELLING ASTRONOMY MAGAZINE

A UNIVERSE WITHOUT GRAVITY

How nature's weakest force does far more than keep our feet on the ground

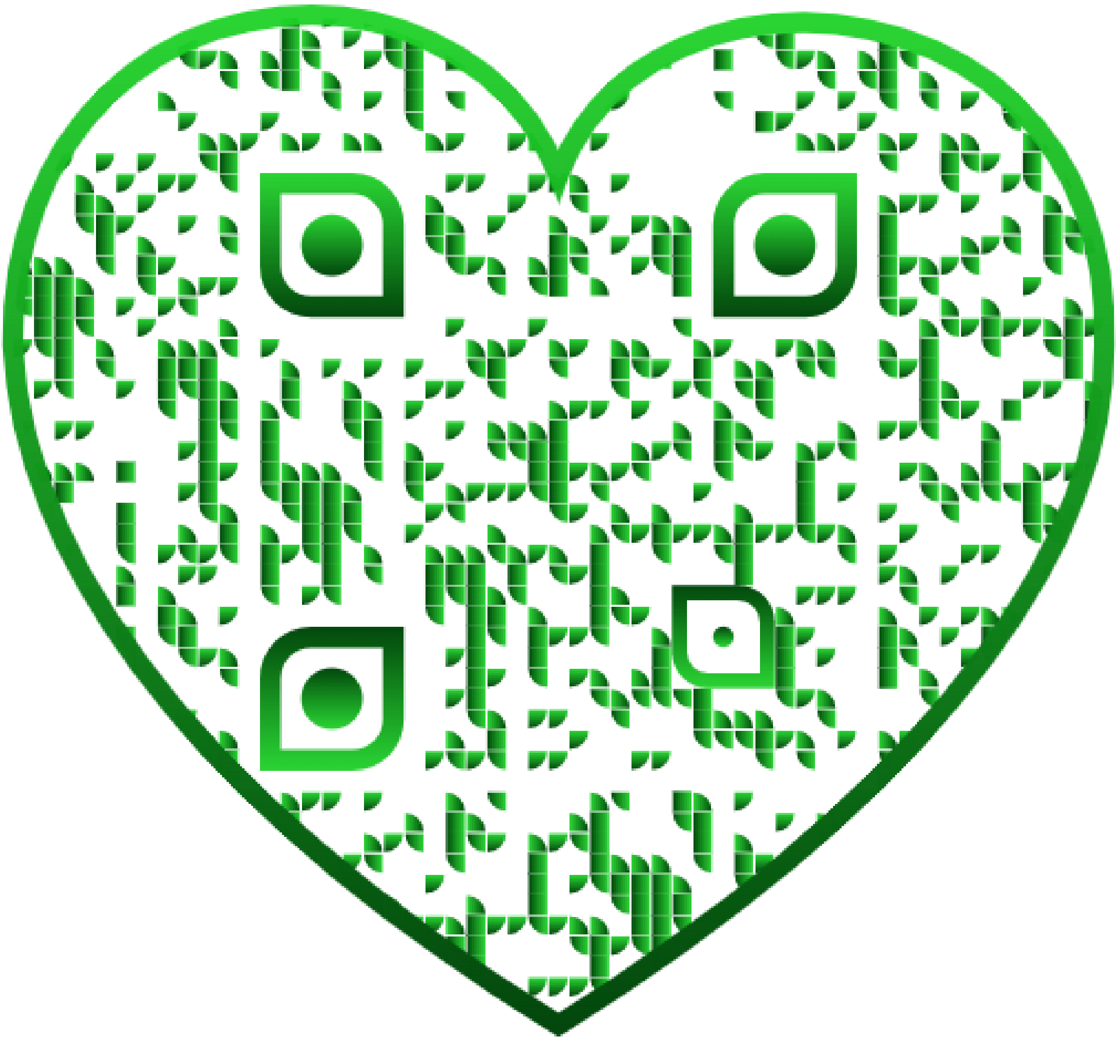
WHAT SCI-FI MOVIES GET WRONG ABOUT SPACE

AI & ASTROPHOTOGRAPHY: FRIENDS OR FOES?

ON TEST: STARFIELD OPTICS' NEW 4-ELEMENT REFRACTOR

RARE TRIPLE-ECLIPSING STAR SETS NEW RECORD

CATCH THE CRESCENT: VENUS LIGHTS UP EVENING SKIES



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Welcome

Life without gravity? It would have its ups and downs

Imagine what would happen, one fine evening in a city, if gravity were to vanish. That's what our cover image – inspired by a painting by the late American space artist Chesley Bonestell – depicts, and I think it gets across that the effects would be pretty profound! Science writer Govert Schilling takes this thought experiment further out into the cosmos in his feature on **page 34**; it turns out that the Universe would be a very different place without nature's weakest force.

One thing we wouldn't have without gravity is meteorites. We often hear from readers who think they may have found one, so we asked meteorite specialist Mark McIntyre to tell us how to identify a rock from space. Turn to **page 60** to read his handy field guide.

We look at another hot topic on **page 66**: the use of AI in astro imaging. Here expert astrophotographer Pete Lawrence gives us an update on this rapidly developing field and offers his thoughts on whether it's possible to apply the technology while still keeping your imaging data unspoiled.

It's National Astronomy Week on 1–9 February, so check out events near you at **www.astronomyweek.org.uk** and read our Sky Guide on **page 43** for this month's best things to see in the night sky. Finally, I thoroughly recommend taking a tip from our Field of View columnist on **page 25**. Stargazer Mark Westmoquette reminds us all to be present in the moment under the stars, taking in a view that's far vaster than our everyday lives. I guarantee you'll feel better for it.

Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale on Tuesday 18 February.

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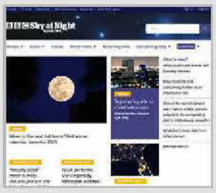
Sky at Night – lots of ways to enjoy the night sky...

Sky at Night

Television

Find out what *The Sky at Night* team have been exploring in recent and past episodes on page 18



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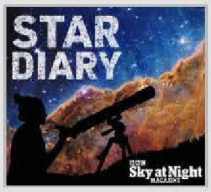

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Discover the best things to see in the night sky every week by listening to our Star Diary podcast

Sky at Night
SPACE IN 2025

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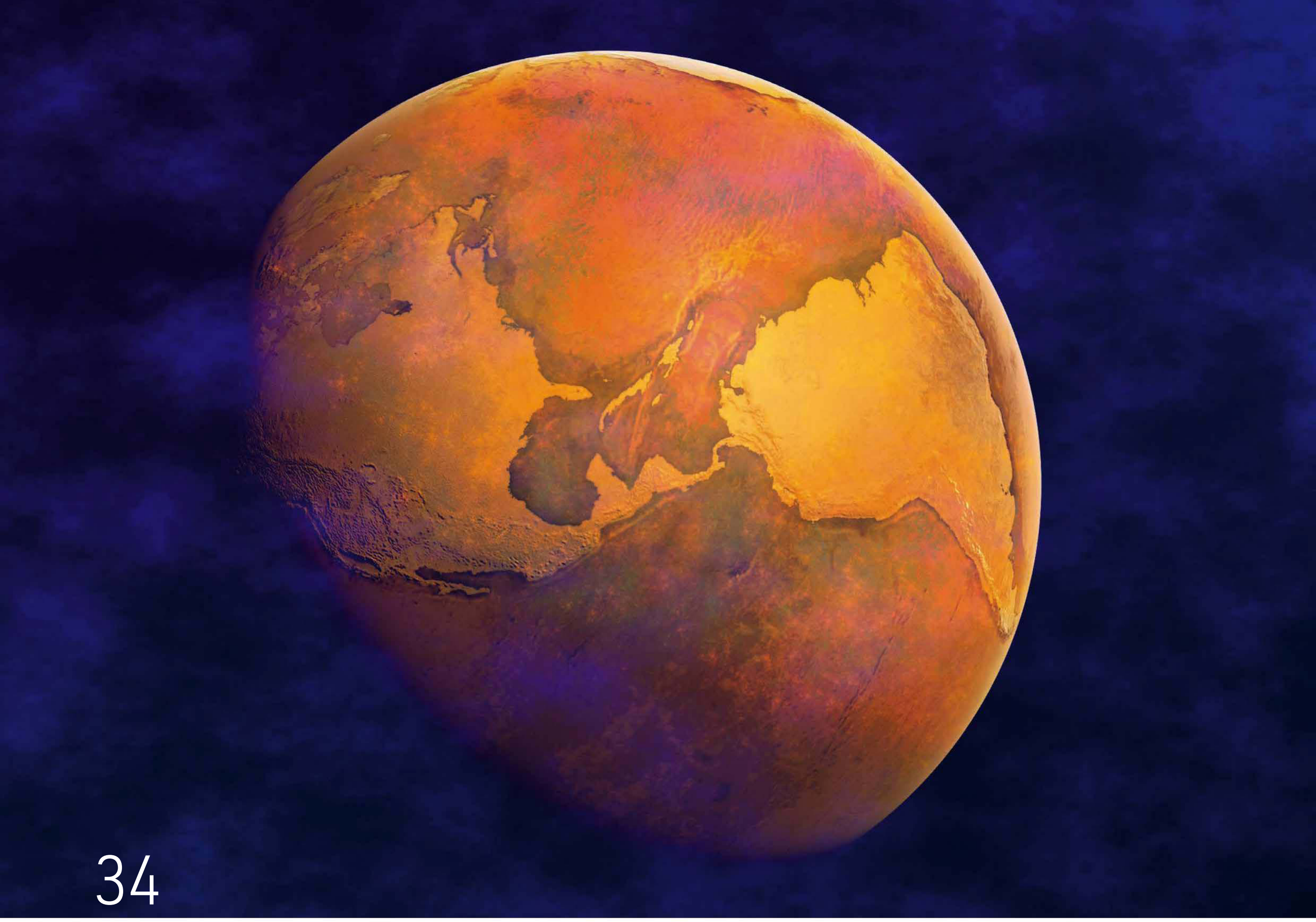

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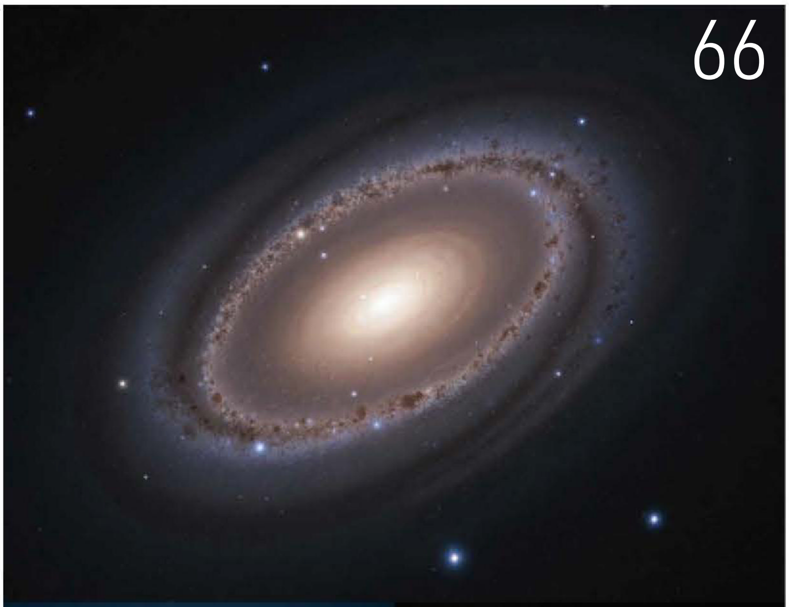
New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**



This month's contributors

Amy Arthur

Science journalist

"We all love a bit of sci-fi, but how much real science is there among the fiction? I loved delving into some of my favourite movies to discover whether what we see on screen would really happen in space." **Read more on page 28**

Govert Schilling

Astronomy author

"It was great fun to explore what a Universe without gravity would be like. Luckily, it's just a thought experiment or you wouldn't be around to read the story!" **Float to page 34 to learn how much we rely on gravity**

Mark McIntyre

Meteorite expert

"We now have so many eyes on the sky that it's only a matter of time before there's another big meteorite find. Knowing how to identify one has never been more important." **Find out how to spot a space rock, page 60**

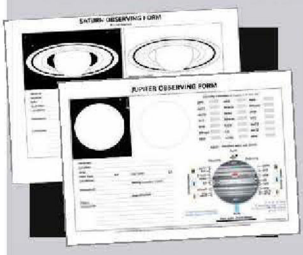
FREE BONUS CONTENT

Find it at **www.skyatnightmagazine.com/bonus-content**

FEBRUARY HIGHLIGHTS

Capturing a star outside our Galaxy

Jacco van Loon reveals how astronomers captured the first close-up image of a star beyond the Milky Way.



Sky at Night
The Messier catalogue

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Keep track of your observations of the Sun and the planets through the eyepiece with our printable forms.

Messier poster for your digital device

Download our poster of the complete catalogue, along with coordinates so you can tick off each one at your scope.

The Virtual Planetarium

Beta Eridani
Beta Orionis
IC 2118

Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

NO PLACE TO CALL HOME

It's a struggle to build planets when your neighbours are massive stars

CHANDRA X-RAY OBSERVATORY/SPITZER SPACE TELESCOPE, 28 OCTOBER 2024

This image of Cygnus OB2, the closest large star cluster to Earth, was created by combining X-ray data with observations from the now-defunct Spitzer Space Telescope. The result confirmed something scientists had long suspected: that the protoplanetary discs of smaller stars can be adversely affected by the presence of massive stars nearby.

X-rays and UV light coming from such stars can act like a wind, blowing material out of the smaller stars' discs before planets have the chance to form. In regions of Cygnus OB2 with few stars and low radiation, around 40 per cent of young stars had protoplanetary discs; however, in regions with more massive stars and higher radiation, that figure fell to a mere 18 per cent.

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Explore a gallery of these and more stunning space images

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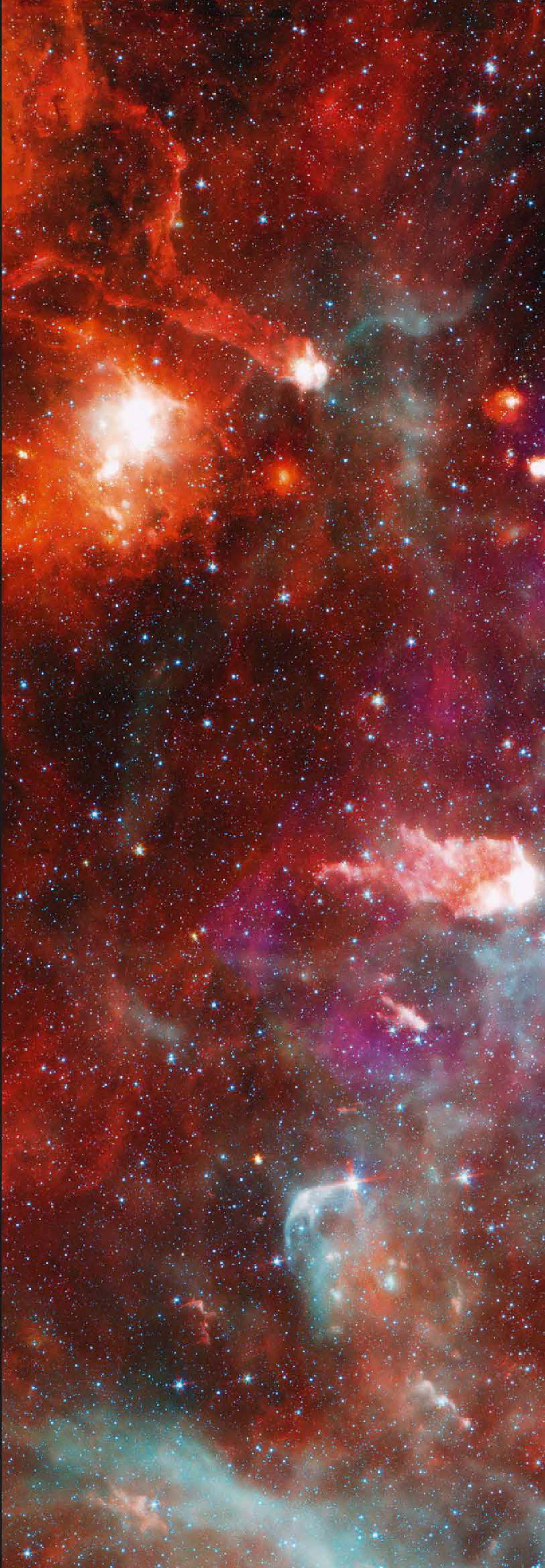
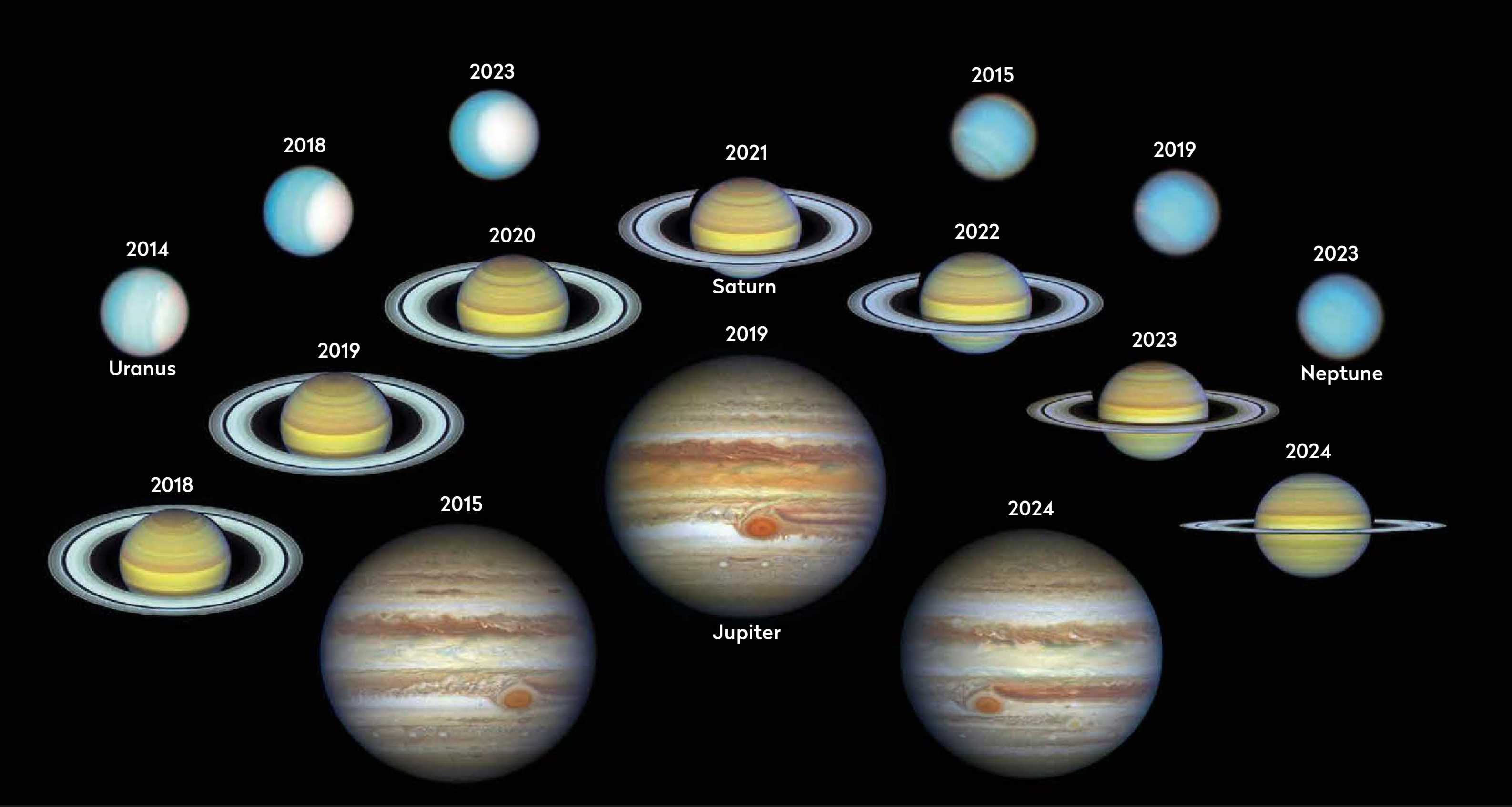


X-RAY: NASA/CXC/SAO/J. DRAKE ET AL/IR: NASA/JPL-CALTECH/SPITZER/IMAGE PROCESSING: NASA/CXC/SAO/N. WOLK



△ OPAL fruits

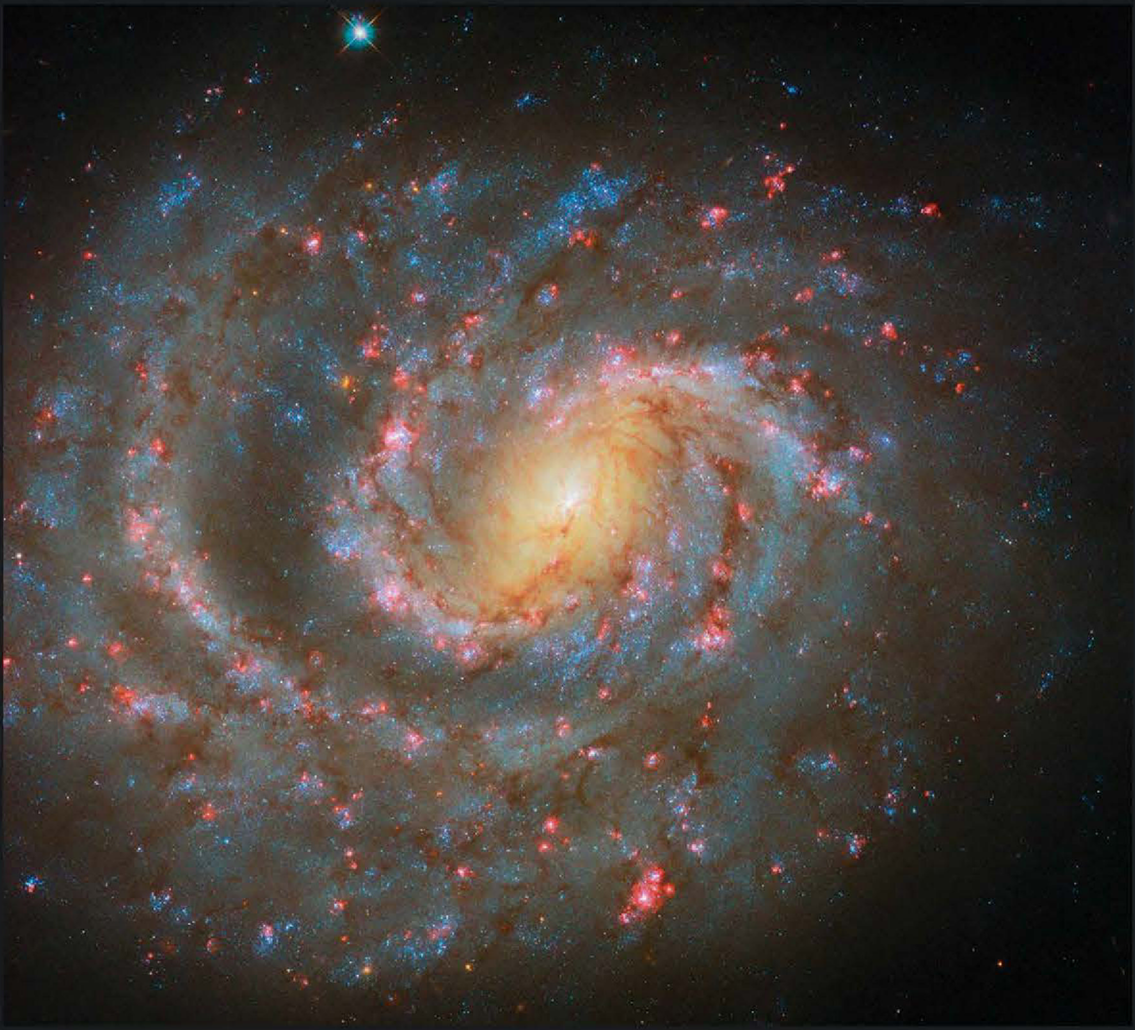
HUBBLE SPACE TELESCOPE, 9 DECEMBER 2024

Hubble's OPAL (Outer Planet Atmospheres Legacy) programme has been studying the atmospheres of the outer Solar System planets for a decade now. This composite shows the changing faces of Jupiter, Saturn, Uranus and Neptune over the years. Note how Saturn's tilt has changed each year so its rings have become more edge-on as seen from Earth.

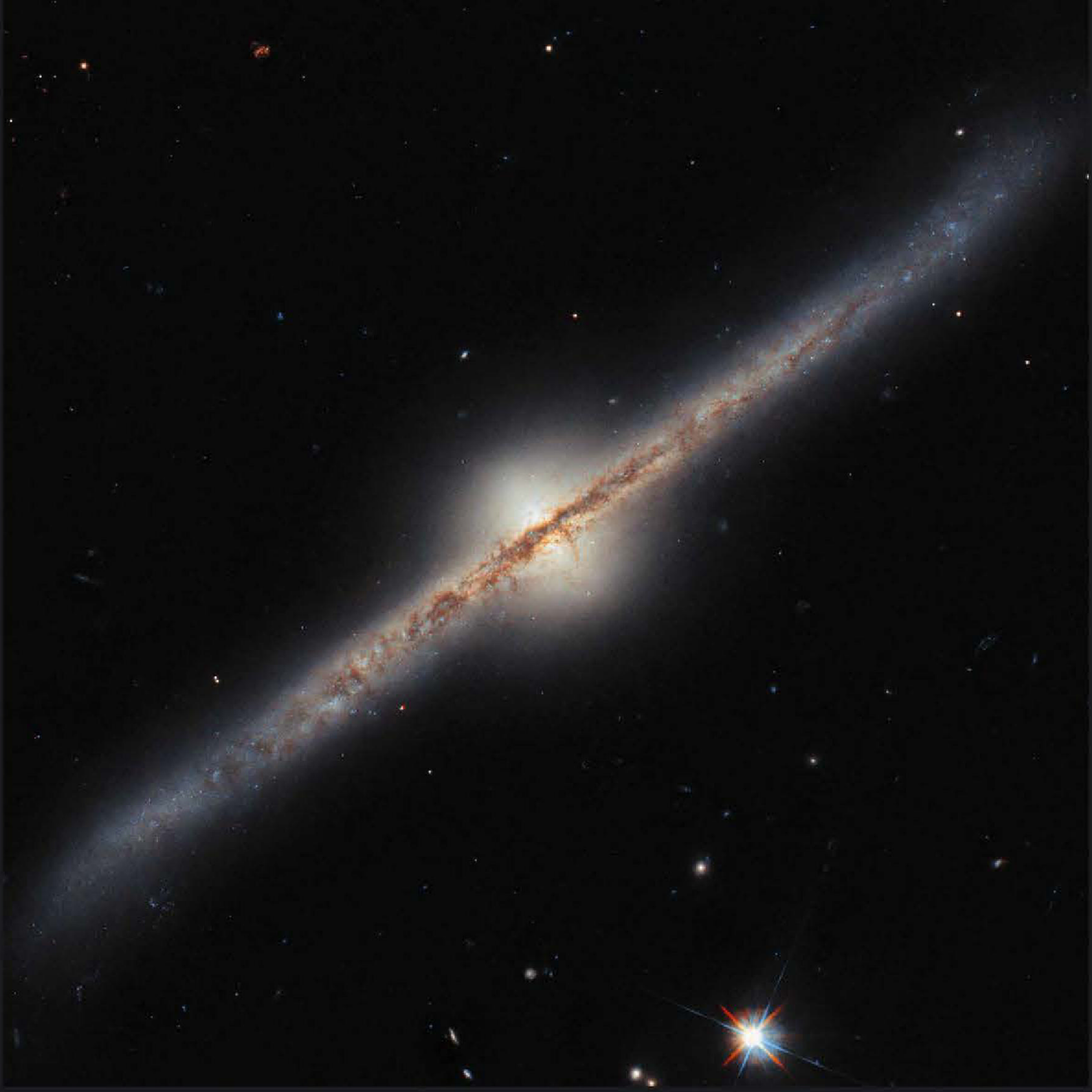
In the pink ▷

HUBBLE SPACE TELESCOPE, 2 DECEMBER 2024

This is NGC 1637, a spiral galaxy in the constellation of Eridanus, the River. The yellow glow at the galaxy's centre comes from its oldest stars, while regions of star formation can be seen in its spiral arms. The pink areas are clouds of hydrogen gas that's been ionised by ultraviolet radiation from newly formed stars, some of which can be seen here as blue dots.



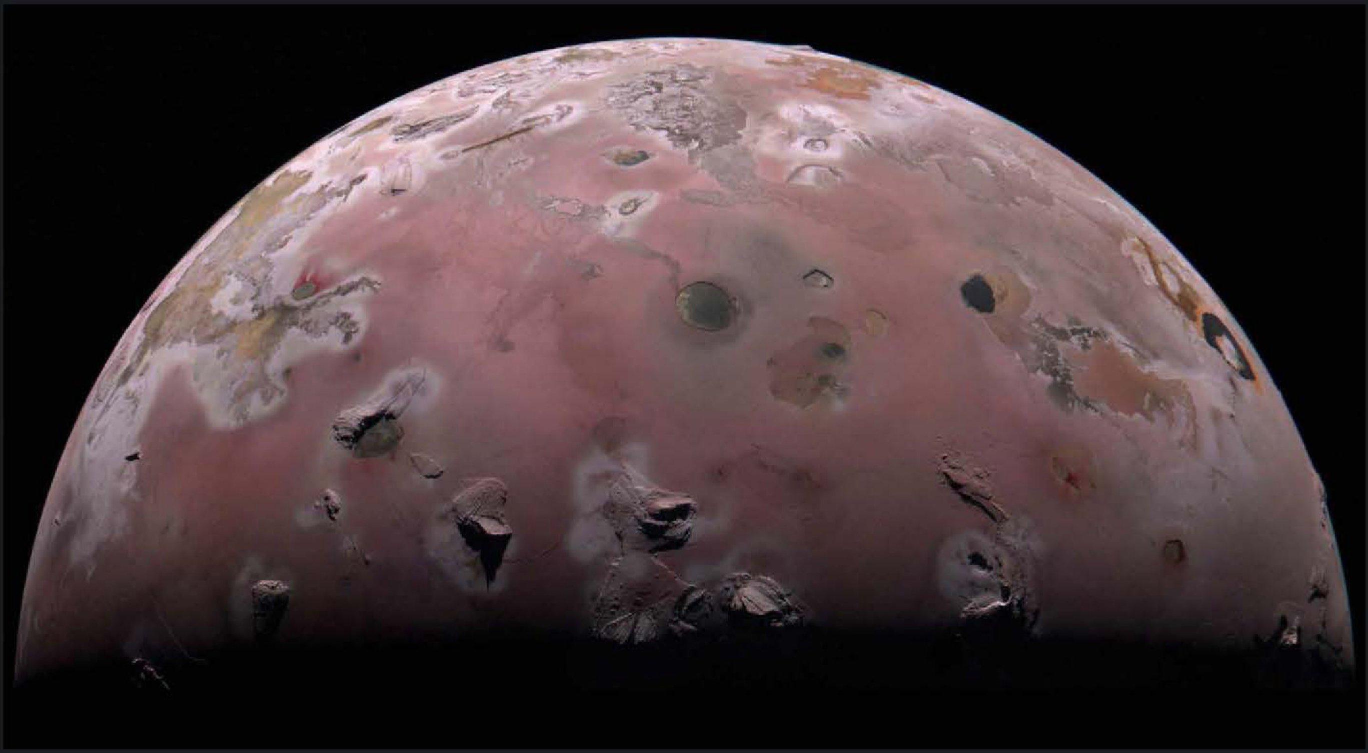
NASA/ESA/AMY SIMON (NASA-GSFC)/MICHAEL H. WONG (UC BERKELEY)/IMAGE PROCESSING: JOSEPH DEPASQUALE (STSCI), ESA/HUBBLE & NASA/D. THILKER, ESA/HUBBLE & NASA/R. WINDHORST/W. KEEL, IMAGE DATA: NASA/JPL-CALTECH/SWRI/MSSS/IMAGE PROCESSING: GERALD EICHSTÄDT



◁ Side-on spiral

HUBBLE SPACE TELESCOPE, 22 NOVEMBER 2024

This spectacular Hubble image shows spiral galaxy UGC 10043, 150 million lightyears from Earth in the constellation Serpens. You wouldn't know it's a spiral from this image, because the galaxy appears sideways-on when seen by Hubble, with the result that its arms aren't visible – but its central bulge is.



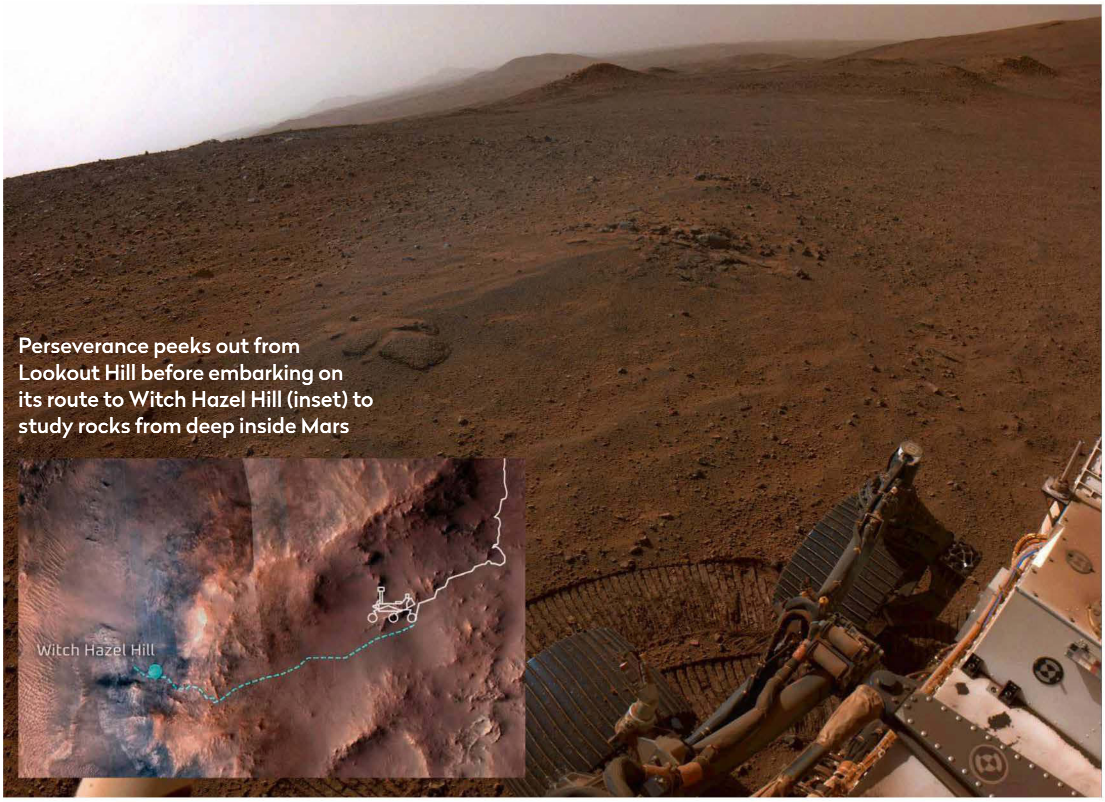
△ Pole position

JUNO, 12 DECEMBER 2024

This jaw-dropping picture of the north pole of Jupiter's moon Io, captured during a Juno fly-by in December 2023, has just been released to accompany new research. The latest findings disprove the idea that Io's many volcanoes are fed by a single subsurface magma ocean and instead suggest that they're powered by their own individual chambers of hot magma.

The latest astronomy and space news, written by Ezzy Pearson

BULLETIN



Perseverance peeks out from Lookout Hill before embarking on its route to Witch Hazel Hill (inset) to study rocks from deep inside Mars

Perseverance reaches crater's rim

NASA's intrepid Mars rover is now exploring the high plains around Jezero

After a long, arduous climb, NASA's Perseverance rover has finally reached the top of Jezero Crater's rim. It took the rover three and a half months to vertically ascend 500 metres (1,640ft), at times creeping up slopes with a 20 per cent gradient, emerging in a region known as Lookout Hill.

"Our rover drivers have done an amazing job negotiating some of the toughest terrain we've encountered since landing," says Steven Lee, Perseverance's deputy project manager at NASA's Jet Propulsion Laboratory. "They developed innovative approaches to overcome these challenges – even tried driving backward to see if it would help – and the rover has come through it all like a champ."

Perseverance is now set to begin its fifth science campaign, dubbed 'Northern Rim'. Over the next year, it will traverse around 6.4km (4 miles), visiting four sites of geological interest to take measurements and collect samples to add to the cache already taken from within the crater, with the hope of later returning them to Earth for study.

"The Northern Rim campaign brings us completely new scientific riches as Perseverance roves into fundamentally new geology," says Ken Farley, project scientist for Perseverance at Caltech. "It marks our transition from rocks that partially filled Jezero Crater when it was formed by a massive impact about 3.9 billion years ago to rocks from deep down inside Mars that were thrown upward to form the crater rim after impact."

Perseverance now has a golden opportunity to study geology usually hidden deep beneath the planet's surface. The rover will initially head to a layered rocky outcrop around 450 metres (1,500ft) away, called Witch Hazel Hill.

"The campaign starts off with a bang because Witch Hazel Hill represents over 100 metres (330ft) of layered outcrop, where each layer is like a page in the book of Martian history. As we drive down the hill, we will be going back in time," says Candice Bedford, a Perseverance scientist from Purdue University. **www.jpl.nasa.gov**

Comment

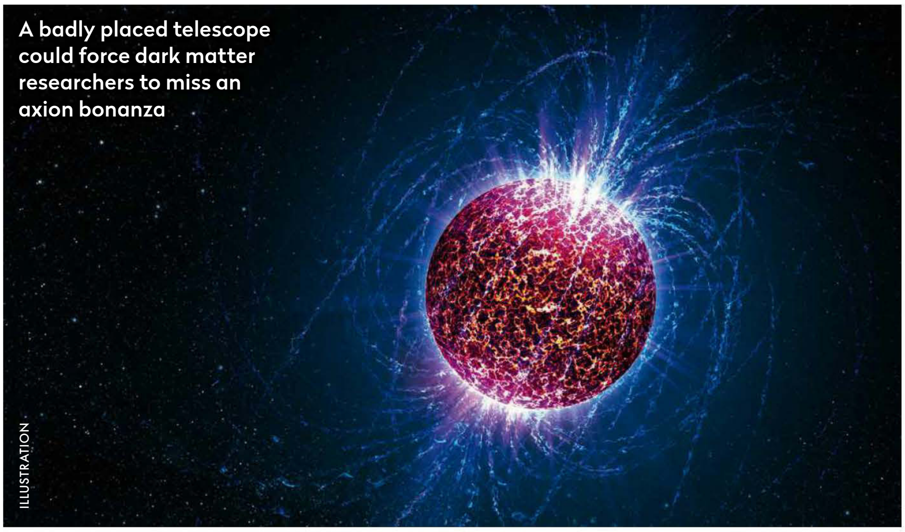
by Chris Lintott

Perseverance carries with it a well-travelled fragment of rock – a tiny sliver of a meteorite recovered from the deserts of Oman 25 years ago, SaU008, which seems to have come from Mars. By taking a bit of Mars that we've prodded in terrestrial labs back to the Red Planet, it's possible to calibrate the data the mission sends back home.

It also seems to me to be a symbol, a piece of a planet lost billions of years ago, now returned home as part of a mission to understand the history of this very alien place. Perseverance's aim is to return the favour, gathering samples that might one day be brought back to Earth; whether funding will allow this remains to be seen. Fingers crossed.

Chris Lintott co-presents *The Sky at Night*

NASA/JPL-CALTECH, NASA/JPL-CALTECH/ESA/UNIVERSITY OF ARIZONA, CASEY REED/ COURTESY OF PENN STATE, MARK GARLICK/SCIENCE PHOTO LIBRARY/GETTY


A badly placed telescope could force dark matter researchers to miss an axion bonanza

Dark matter clue could go to waste

Astronomers may miss a huge hint in the hunt for dark matter

A nearby supernova could potentially end the search for dark matter according to a new study, provided astronomers don't miss it.

The study looked at one of the leading candidates for dark matter, a hypothetical particle known as the axion. These are thought to be created during the first 10 seconds of a supernova explosion. The intense magnetic field converts some of the axions into gamma rays, creating a burst that can be seen from Earth. By studying these gamma rays, astronomers would be able to measure the axion's mass.

"We'd be able to determine everything we need to know about the axion, and we'd be incredibly confident in the signal because there's no ordinary matter which could create such an event," says Benjamin Safdi from the University of California, Berkeley, who took part in the study.

The issue is that currently only the Fermi Gamma-ray Space Telescope could detect such a burst, and only if it happens in the Milky Way or one of its satellites – an event that occurs once every few decades. There's only a 1 in 10 chance that Fermi would be looking in the right place when it happens. The study discusses the feasibility of a network of gamma-ray telescopes to cover the whole sky, ensuring such a burst would be caught.

"It would be a real shame if a supernova went off tomorrow and we missed an opportunity to detect the axion – it might not come back for another 50 years," says Safdi. **fermi.gsfc.nasa.gov**

Venus has always been dry

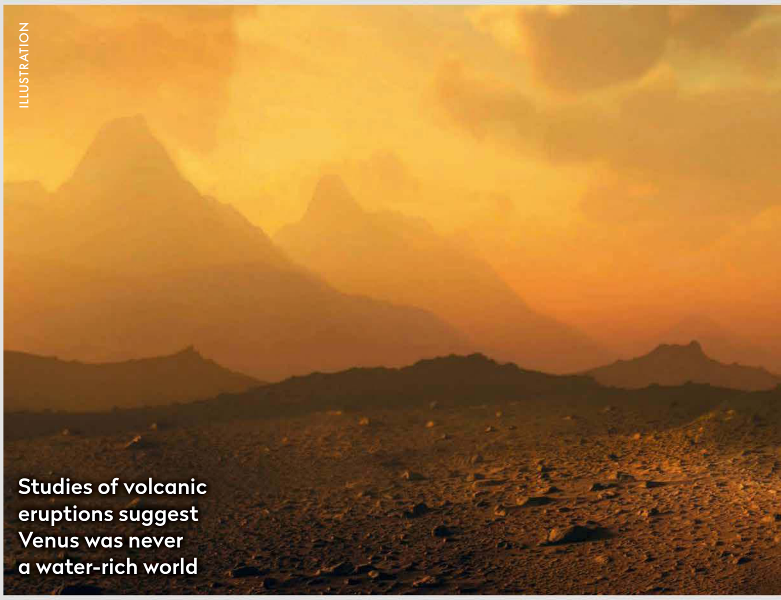
Research into volcanic eruptions suggests Venus was never a water-rich world

Despite hopes that Venus may have once had oceans of water, a new study has found that the planet has probably been dry since its creation 4.6 billion years ago. This means it's highly unlikely any Earth-like life evolved on the planet.

High levels of volcanic activity ensure Venus is covered in a thick carbon-dioxide atmosphere which insulates the planet. Today, this has increased the temperature to the point where any surface water has long since boiled away, but planetary geologists have postulated that the past climate may have been cooler, allowing oceans to form.

To test this, a team of researchers looked at what other gases Venus's volcanoes were pumping into the atmosphere. Here on Earth, volcanic eruptions are mostly steam as our planet's interior is water-rich. On Venus, however, it seems the eruptions are only six per cent steam, indicating the planet is extremely dehydrated and probably always has been.

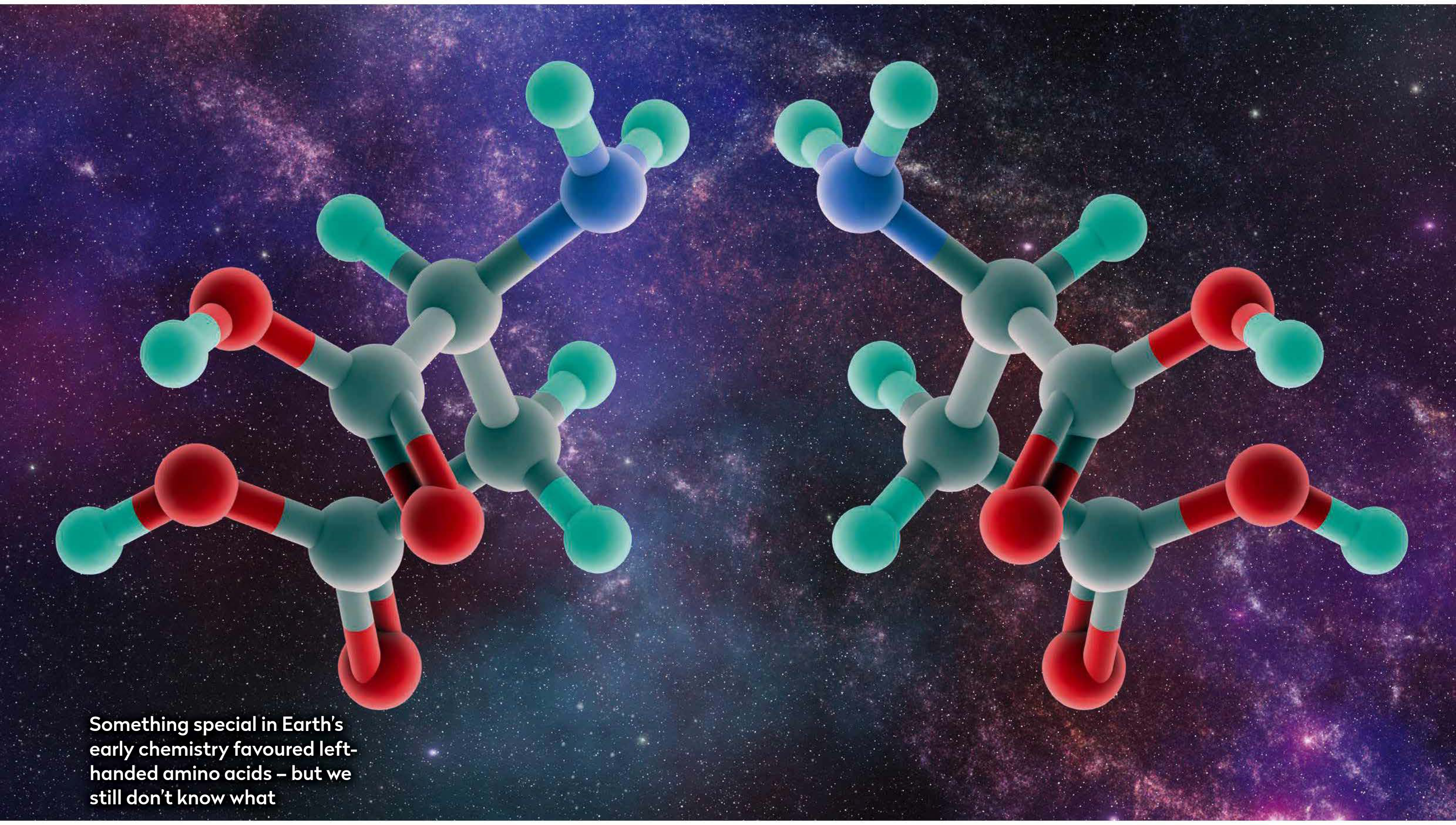
"We won't know for sure whether Venus can or did support life until we send probes at the end of this decade," says Tereza Constantinou from the University of Cambridge. "But given it likely never had oceans, it is hard to imagine Venus ever having supported Earth-like life, which requires liquid water."



Studies of volcanic eruptions suggest Venus was never a water-rich world

The find is significant for astrobiologists looking for life not just within our Solar System, but beyond it too. "Even though it's the closest planet to us, Venus is important for exoplanet science, because it gives us a unique opportunity to explore a planet that evolved very differently to ours, right at the edge of the habitable zone," said Constantinou.

Earth and Venus are very similar in size, mass and composition. However, while Earth is teeming with life, Venus is extremely hostile to it. The discovery reinforces how difficult it may be to determine which exoplanets might truly be habitable. **www.phy.cam.ac.uk**



Something special in Earth's early chemistry favoured left-handed amino acids – but we still don't know what

Mystery over life's 'handedness' grows

No one knows why the building blocks of life all point the same way

All the molecules of life on Earth are orientated the same way, but the reason why that's the case is one of the biggest enigmas facing evolutionary biologists investigating the origins of life. Now a new NASA study has only served to deepen the mystery by revealing there's no reason why one orientation would be favoured over another.

Earth life is based around proteins. These biomolecules are built from 20 amino acids which combine in different orders to create everything from enzymes to muscle and bone cells. Some of these amino acids can exist in two forms, each a mirror of the other, which are referred to as being right- or left-handed. Scientists call this handedness a molecule's 'chirality'. For some reason, life on Earth exclusively uses left-handed amino acids.

One theory is that the molecules found on Earth before life emerged may have favoured one chiral structure over the other. To investigate this, a team of researchers recreated the conditions that may have been present on early Earth in a lab. They incubated solutions of ribozymes – an RNA molecule that might have been a precursor to DNA – and amino acids, to see whether they favoured one chirality over another.

"The experiment demonstrated that ribozymes can favour either left- or right-handed amino acids," says Irene Chen, from the University of California, Los Angeles, one of the study's authors. Such versions of early Earth "would not necessarily have a strong bias for the form of amino acids we observe in biology now".

It could be later evolutionary pressure that favoured one handedness over another. Unfortunately, our planet's plate tectonics have long since recycled the fossil record of the time, meaning it's impossible to determine exactly when the preference asserted itself. Instead, planetary geologists are searching for clues by looking at comets and asteroids. These are thought to have been one of the main ways that the building blocks of life, including amino acids, were originally delivered to Earth.

"Understanding the chemical properties of life helps us know what to look for in our search for life across the Solar System," says Jason Dworkin from NASA's Goddard Space Flight Center, project scientist on asteroid sample-return mission OSIRIS-REx.

"We are analysing OSIRIS-REx samples for the chirality of individual amino acids," says Dworkin, "and in the future, samples from Mars will also be tested in laboratories for evidence of life, including ribozymes and proteins."

www.nasa.gov

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Mega merger: spheroidal galaxies may spring from the star-forming frenzy after two disc galaxies collide

Cosmic crashes create enormous ellipticals

Flows of cold gas from merging galaxies trigger a burst of star formation

Astronomers could be close to answering the question of how the largest galaxies came together, after studying the birth sites of giant elliptical galaxies in the early Universe.

Elliptical galaxies are spheroidal and much larger than spiral galaxies like our own Milky Way. They are thought to be created when spiral galaxies merge together, but the process behind this hasn't been fully understood. The new study examined 100 star-forming galaxies using the Atacama Large Millimeter/Submillimeter Array (ALMA) in Chile and found that when galaxies collide, gas sinks towards their common centre, triggering the creation of trillions of new stars. Most mergers like this happened between eight to 12 billion years ago.

"This is the first real evidence that spheroids form directly through intense episodes of star formation located in the cores of distant galaxies," says Qing-Hua Tan from the Purple Mountain Observatory, China, who led the study.

"Astrophysicists have sought to understand this process for decades. These galaxies form quickly – gas is sucked inwards to feed black holes and trigger bursts of stars, which are created at rates 10 to 100 times faster than in our Milky Way."
www.southampton.ac.uk

Trump selects new NASA administrator

The appointment of a space entrepreneur awaits approval by the Senate

The billionaire Jared Isaacman has previously commanded two private SpaceX missions

NASA is heading towards a new era after President-elect Donald Trump announced on 4 December 2024 that he'd selected billionaire entrepreneur Jared Isaacman to be the new administrator of NASA.

Originally the founding CEO of a payment-processing company and an aerospace defence company, Isaacman has funded and commanded two commercial spaceflights in recent years: Inspiration4, the first completely private space mission, in 2021, and Polaris Dawn in 2024, where Isaacman performed the first commercial spacewalk to test spacesuits created by SpaceX.

"I can confidently say this second Space Age has only just begun," Isaacman said shortly after the Trump announcement. "There will inevitably be a thriving space economy – one that will create opportunities for countless people to live and work in space. At NASA, we will passionately pursue these possibilities and usher in an era where humanity becomes a true spacefaring civilisation."

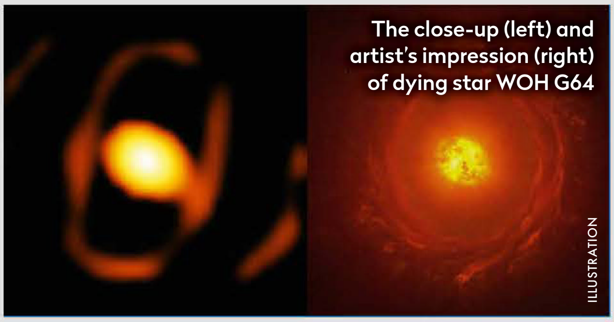
The appointment still needs to be ratified by the Senate, which is expected to closely scrutinise Isaacman's ties with SpaceX, the company that conducted both of his spaceflights, and also one of NASA's major contractors. While it is normal for NASA's administrator to change with a new presidency, the announcement is usually made several weeks or even months after taking office. Isaacman's appointment was made before Trump's agency review team – who help the new administration review NASA's activities – had even arrived at NASA.

One aspect of NASA's work that the Trump administration is expected to scrutinise closely is the Artemis programme. The day after Isaacman's appointment, the agency announced it had pushed back the crewed Artemis II mission to April 2026, while Artemis III, which seeks to place the first woman on the surface of the Moon, has been delayed until mid-2027.

The delays are partly due to issues with the Orion heatshield during the Artemis I mission, when gases released by the ablative coating weren't given sufficient space to escape, causing the surface to crack and fall off. However, temperatures within the capsule remained well within safe limits. **www.nasa.gov**

First close-up of a star outside our Galaxy

Zoomed-in shot shows dying red supergiant before it goes supernova


The close-up (left) and artist's impression (right) of dying star WOH G64

Astronomers have zoomed in on a star going through its final days. Located 160,000 lightyears away in the Large Magellanic Cloud, it's the first time a star beyond the Milky Way has been examined in such detail.

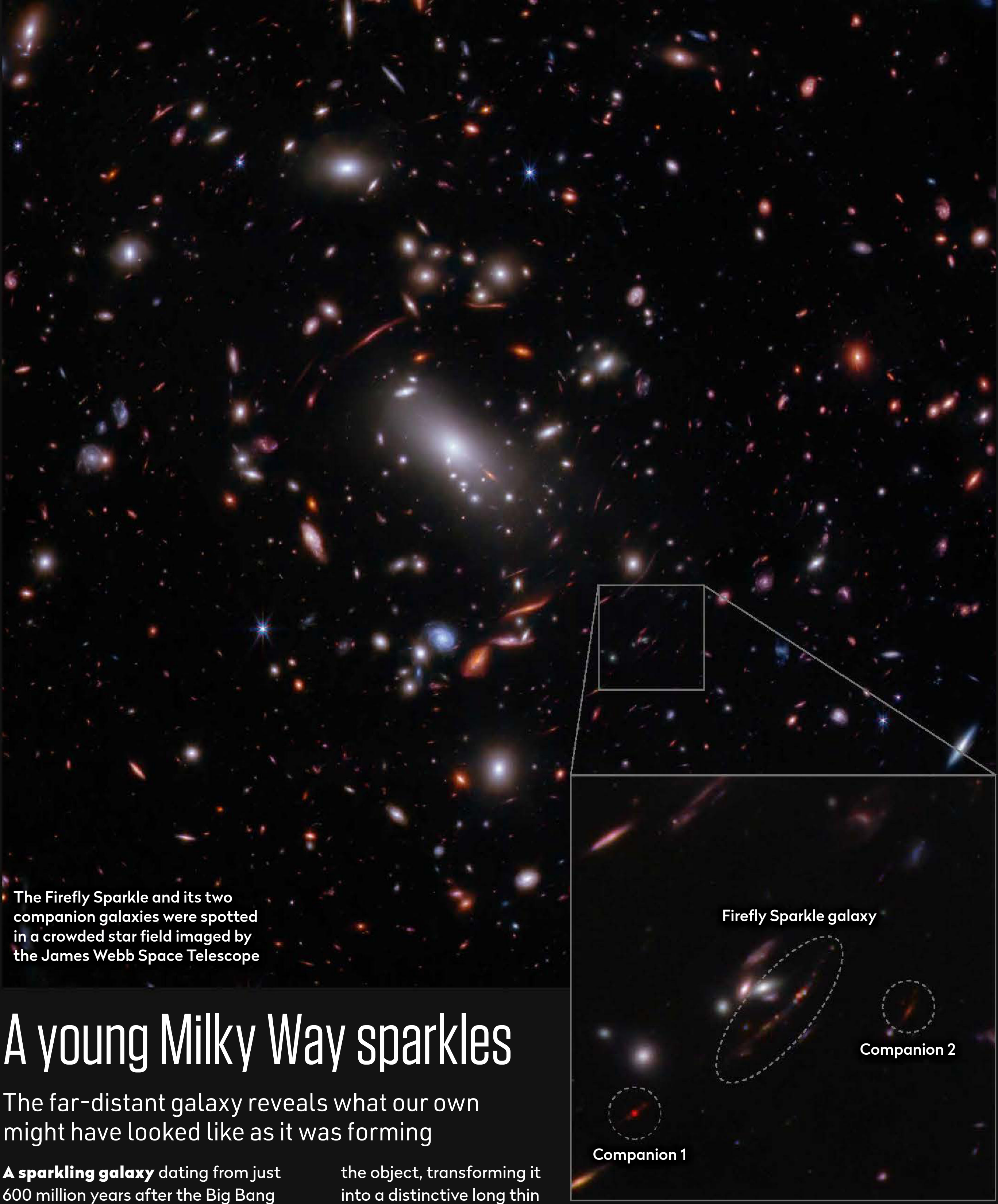
WOH G64 is a truly enormous star, 2,000 times larger than our Sun, making it a red supergiant. Over the last decade, the star has grown dimmer and so a team of astronomers examined it using the Very Large Telescope in Chile to understand why.

"For the first time, we have succeeded in taking a zoomed-in image of a dying star in a galaxy outside our own Milky Way," says Keiichi Ohnaka, from Universidad Andrés Bello in Chile, who led the study. "We discovered an egg-shaped cocoon closely surrounding the star. We're excited because this may be related to the drastic ejection of material from the dying star before a supernova explosion."

When massive stars like WOH G64 reach the end of their lives, before going supernova they swell into red giants. During this phase, they lose their outer layers of gas and dust, creating a cloud around them. WOH's unusual egg shape could be a sign of an unseen companion star shepherding the gas.

"This star is one of the most extreme of its kind, and any drastic change may bring it closer to an explosive end," says Jacco van Loon from Keele University, UK, who has been observing WOH G64 since the 1990s. See page 5 for an interview with Jacco van Loon. **www.eso.org**

POLARIS PROGRAM, ESO/K. OHNAKA ET AL/L. CALÇADA, NASA/ESA/CSA/STSCI/CHRIS WILLOTT (NRC-CANADA) LAMIYA MOWLA (WELLESLEY COLLEGE)/KARTHEIK IYER (COLUMBIA), NASA/ESA/CSA/RALF CRAWFORD (STSCI)



The Firefly Sparkle and its two companion galaxies were spotted in a crowded star field imaged by the James Webb Space Telescope

A young Milky Way sparkles

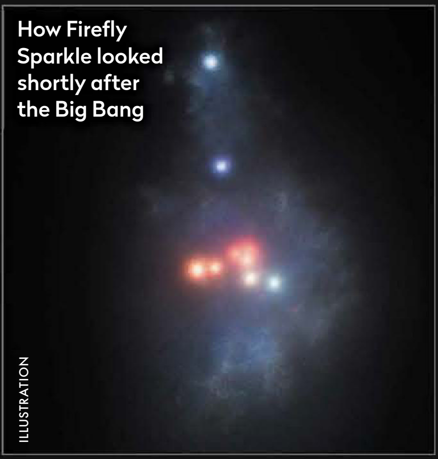
The far-distant galaxy reveals what our own might have looked like as it was forming

A sparkling galaxy dating from just 600 million years after the Big Bang has provided our first-ever glimpse of what a galaxy like our Milky Way looked like just as it was beginning to form.

Astronomers took notice of the galaxy due to the 10 bright star clusters shining within it, the source of its nickname: 'Firefly Sparkle'. On closer inspection they were surprised to find that the galaxy is much lighter than most others we know of in the early Universe and could be an analogue for our own Galaxy's early days.

Firefly Sparkle is visible because it's gravitationally lensed, where its light is bent around a massive foreground galaxy cluster. The effect magnifies but distorts the object, transforming it into a distinctive long thin arc. Fortunately, researchers were able to undo the effect and predict what the galaxy should look like (see right).

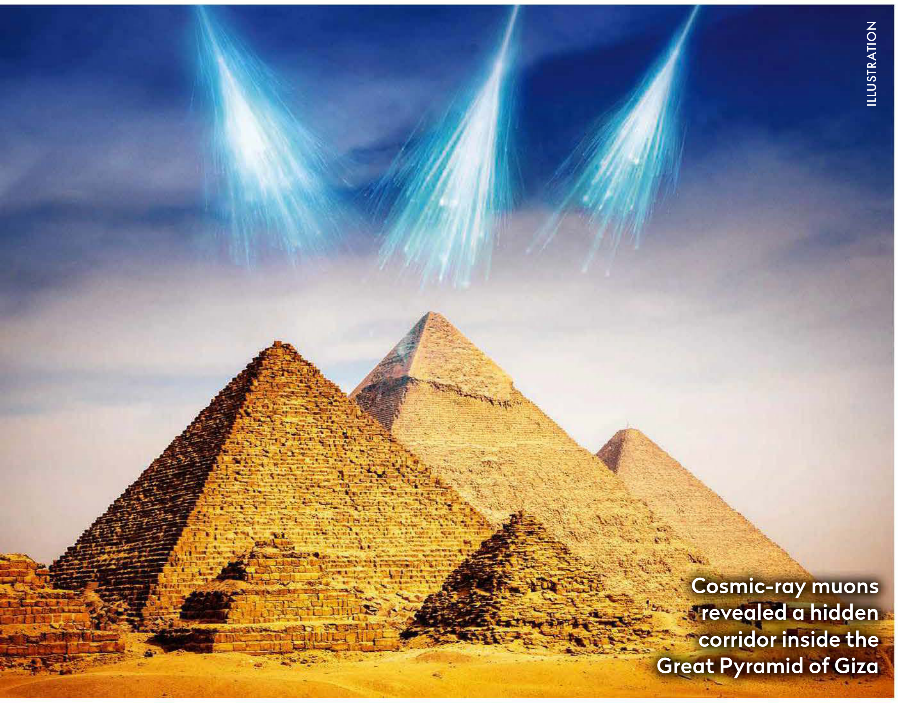
"I didn't think it would be possible to resolve a galaxy that existed so early in the Universe into so many distinct components, let alone find that its mass is similar to our own Galaxy's when it was in the process of forming," says Lamiya Mowla from Wellesley College, Massachusetts, who took part in the study. "With Firefly Sparkle, we are witnessing a galaxy being assembled brick by brick."
www.webbtelescope.org



How Firefly Sparkle looked shortly after the Big Bang

Our experts examine the hottest new research

CUTTING EDGE



Cosmic-ray muons revealed a hidden corridor inside the Great Pyramid of Giza

Putting cosmic rays to work

These penetrating interstellar particles have applications from astronomy to archaeology

Cosmic rays are high-energy subatomic particles that zip around in outer space. They're accelerated to enormous speeds by astrophysical events like coronal mass ejections on the Sun or supernovae exploding across the Galaxy. When one encounters planet Earth, it soon hits a gas atom high in the atmosphere, creating a burst of other particles which themselves fly forwards to trigger further interactions, until a huge cone-shaped cascade of different particles develops.

This cosmic radiation is a hazard not just for astronauts, but also for passengers and aircrew flying high in the atmosphere – especially on routes over the poles, where the protection from the planet's magnetic field is weakest. Much of these 'secondary cascades' are absorbed by the atmosphere, but some of the more penetrating particles do reach Earth's surface, in particular muons, but also some neutrons, electrons and gamma rays.

There's a lot of interest, then, in understanding how these cosmic rays propagate through the atmosphere. Several computer models have been created over the years, and now Olesya Sarajlic and Xiaochun He, both in the Department of Physics and Astronomy at Georgia State University, Atlanta, have released a new simulation package they claim offers greater flexibility than others. Their Earth Cosmic Ray Shower (ECRS) software is based on Geant4, a particle physics modelling platform created at CERN, and can simulate how the radiation environment changes with increasing altitude, across latitudes between the poles and the equator, and also with variations in Earth's atmosphere and magnetic field.

Getting the inside story

Sarajlic and He's new model represents a substantial update from an earlier version created in 2007. I must confess a personal interest in this work: in that same year, I was using my own Geant4-based computer model to study the cosmic rays penetrating the topsoil of Mars, to understand how long any Martian microbes might be able to survive the radiation.

But what really caught my eye about this new paper was how their updated model could be used to improve all the applications of cosmic rays. These high-energy radiation particles are not only a hazard; they also offer some really neat uses.

One major area exploiting cosmic rays is in using the natural flow of muons from the atmospheric cascades in the same way that X-rays are used to take images through the human body, but on much larger scales. X-rays are blocked by just a few centimetres of metal or rock, but cosmic-ray muons can penetrate several metres of solid rock. Such 'muon tomography' was used in 2017 to scan the interior structure of the Great Pyramid of Giza, leading to the discovery of a large, previously unknown cavity hidden above the Grand Gallery.

"X-rays are blocked by just a few centimetres of metal or rock, but cosmic-ray muons can penetrate several metres of solid rock"

This technique could also be used to detect if someone was trying to smuggle a chunk of uranium in a shipping container, for example, or to safely examine inside a damaged nuclear reactor such as at the Fukushima plant in Japan. Sarajlic and He's updated cosmic-ray model could improve all these sorts of practical applications.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *Novel Simulation Framework for Analyzing Cosmic Ray Particle Distributions at a Global Scale* by Olesya Sarajlic and Xiaochun He **Read it online at: arxiv.org/abs/2411.03142**

KITTI BOONNITROD/GETTY, NASA/ESA/HUBBLE/JWST/FREDERIC DUX

The first 'zig-zag' gravitational lens

A distant quasar's light is spotted being bent by not one, but two lenses

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

What we consider remarkable has changed over time. When Einstein realised that his general theory of relativity predicted that the path taken by light would be bent by massive objects, neither he nor anyone else would have believed that, a little more than 100 years later, we'd see the phenomenon on galactic scales.

The first gravitational lens was only found in 1979, but we now have thousands of examples where a coincidence of position means that we get a distorted and often magnified image of a distant system which would otherwise be hidden behind a nearer cluster or galaxy.

As surveys get deeper and we're better able to spot unusual things, marvels such as perfect Einstein rings, where light from a distant galaxy is bent into a circle around a lensing object, may not have the blockbuster appeal they once did. The paper I've been reading this month, led by astronomers at the European Southern Observatory, is a reminder that new and unusual lenses are still out there to be found.

One object hit for six

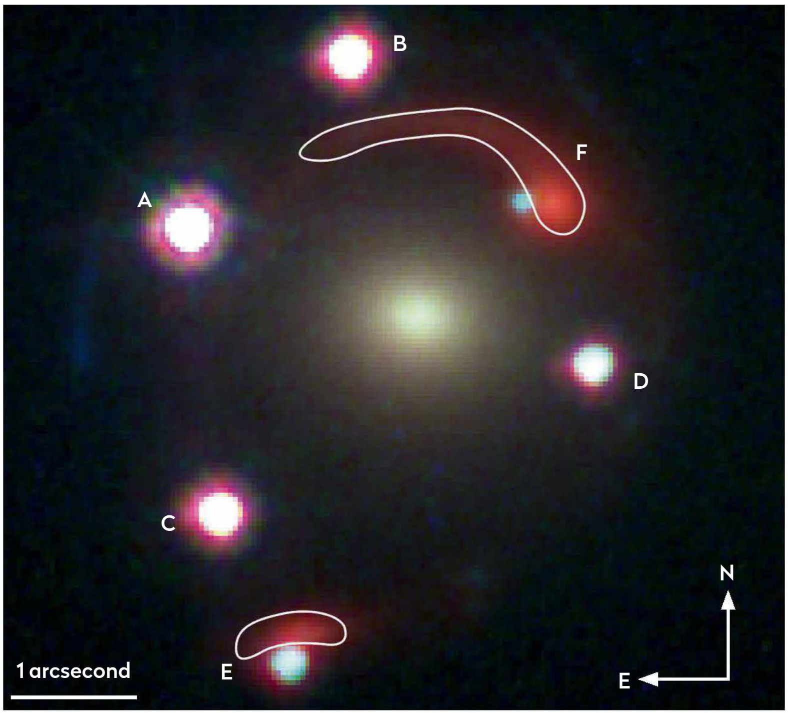
The team studied a system known as J1721+8842, which previous work had suggested was a double quasar, lensed by a nearby galaxy to form six separate images. The truth is much odder.

Careful monitoring with the Nordic Optical Telescope in the Canary Islands showed that each of the lensed images is changing in brightness, and the pattern of brightening and fading is the same for each of them. Though shifted from image to image by up to 39 days, the pattern is exactly the same; these must be images of the same, single object.

New results from the James Webb Space Telescope, which provides spectra and deep imaging of the system, show that there are actually two different lenses involved. Light from a single background quasar first encounters a galaxy at a redshift of 1.9 (far enough away that its light has been travelling towards us for about 10 billion years). It then passes another galaxy at a redshift of 0.19, a bit less than a billion lightyears away, creating more images. The delays in the changing brightness of the different images are caused by the different lengths of the paths that the light takes to get to us. Two of the six images even seem to have been created by 'zig-zag' paths, passing on one side of the more distant galaxy and then the other side of the nearer, second galaxy, the first time that such a lens has been seen.

> ***"Previous work suggested the system was a double quasar, lensed by a nearby galaxy to form six separate images. The truth is much odder"***

Modelling the system should allow the precise masses of the lensing galaxies to be calculated – no small feat, given that one of them is the most distant confirmed lensing system yet found. But cosmologists will be even more excited to study those time delays, as they depend on the expansion rate of the Universe. As there's currently a 'tension' between different ways of measuring this expansion rate, the chance to use this weird system to make an accurate, independent measurement will ensure J1721+8842 gets plenty of attention in the next few years.



▲ The single quasar was observed six times (A to F) as its light took a zig-zag path via one galaxy (shown in white arcs) and then another

Chris Lintott was reading... *J1721+8842: The First Einstein Zig-zag Lens* by F Dux et al. **Read it online at: arxiv.org/abs/2411.04177**

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT

Back in September 2021, *The Sky at Night* show spoke to **Carly Howett** about NASA's then upcoming Lucy mission. As the spacecraft now approaches its main targets – the Trojan asteroids – we check in with her to see how the mission is going

When I last wrote about NASA's Lucy mission, we were waiting for it to launch, beginning its journey to three main-belt asteroids (the ones between Mars and Jupiter) before reaching its eight primary targets, the Jupiter Trojan asteroids. The Trojans are previously unexplored asteroids which lead and trail Jupiter in its orbit. They are remnants of planet formation and likely hold clues to how our Solar System evolved.

Lucy lifted off on a beautiful clear morning on 16 October 2021. Since then, it's been on quite an adventure. While the launch was perfect, it quickly became apparent that the deployment of Lucy's 7-metre-diameter (23ft) solar panels was not. While Lucy had one fully opened solar panel that was latched and rigid, the other didn't open all the way.

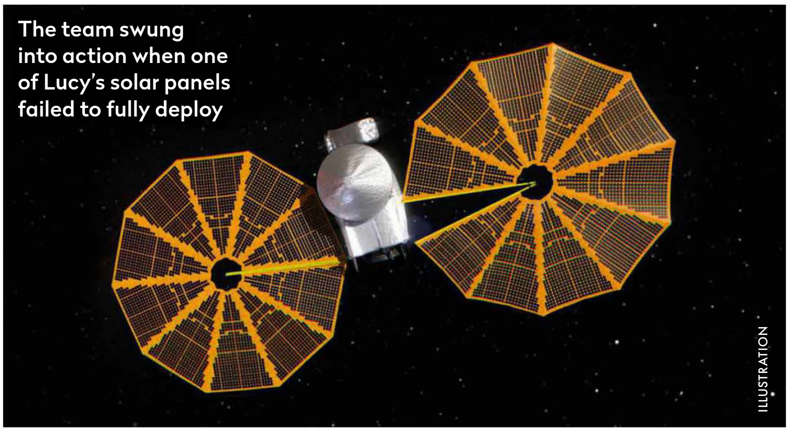
'Floppy' is not a word you want to associate with a spacecraft. It means that when you fire your engines, it's hard to understand how your craft will move. However, the solar panels were creating enough power to operate Lucy and the perfect launch put us on a trajectory that required very little change, giving the engineers time to work on techniques to mitigate the problem.

Hack keeps Lucy on track

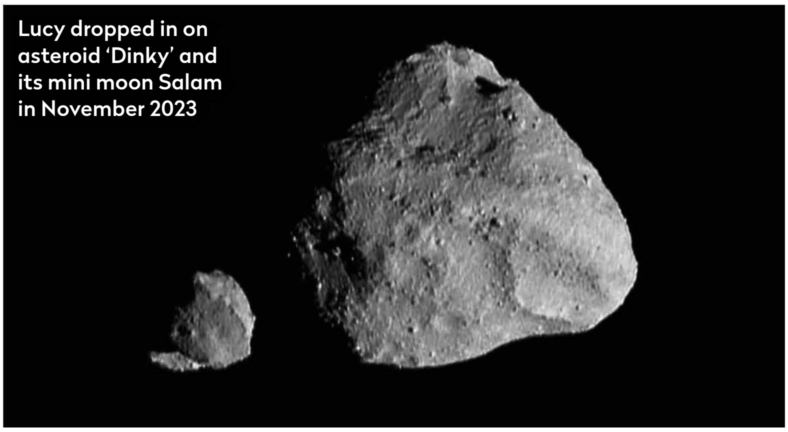
But what was the problem? The device to unfurl the panels resembles a fishing line; when the line reels in, it pulls open the panels. The engineers determined that on one of the panels the line came off the spool and so required more and more force to reel open the panels, eventually stopping when it required more force than the spacecraft was 'authorised' to give.

The Lucy team adapted, making new models to investigate the problem. New trajectories were designed that didn't require the main engines, and novel ways of opening the solar panels were developed. After much consideration, the team opted to try opening the solar panel further. The trade was simple: apply enough force to open the solar panel, but not so much that the line broke.

Solar System explorer Lucy took off aboard an Atlas V in October 2021



The team swung into action when one of Lucy's solar panels failed to fully deploy



Lucy dropped in on asteroid 'Dinky' and its mini moon Salam in November 2023

Eventually, after much testing, the 'Go' was given to attempt to open the solar panels more. Following a 'slowly, slowly, carefully, carefully' approach, the panel was eventually pulled open to a point that it was thought the spacecraft would survive a main-engine burn.

During this time another surprise surfaced – this time a good one! Lucy was found to be flying within 64,000km (39,800 miles) of a main-belt asteroid. This

NASA/BILL INGALLS, NASA'S GODDARD SPACE FLIGHT CENTER CONCEPTUAL IMAGE LAB, NASA/GODDARD/SWRI/JOHNS HOPKINS APL/NOIRLAB, EVGENIYSHKOLENKO/ISTOCK/GETTY

doesn't sound all that close, but remember space is big and so this chance encounter is like being next door. It was too good an opportunity to pass up and NASA agreed to let the Lucy team investigate the small (790-metre (2,592ft)) target. The asteroid was designated 152830 Dinkinesh, or Dinky to its friends!

On 1 November 2023, Lucy flew past Dinkinesh and it truly lived up to its name. It revealed a wonderfully intriguing world with its own surprise: a 220-metre-diameter (722ft) moon they called Salam. The encounter was a complete success, all of Lucy's instruments successfully observed the system and the results are currently being analysed. Stay tuned!

Carly Howett is an associate professor at the University of Oxford and an instrument scientist on the Lucy mission

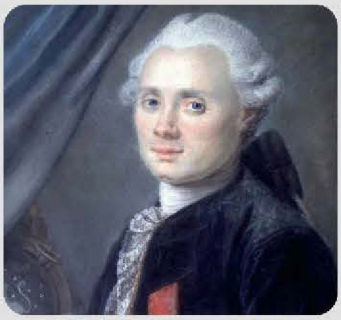
After the encounter, it was finally time for Lucy to conduct a major engine burn. Despite the models, the theories and the calculations looking good, there was still a great amount of breath-holding, finger-crossing and other superstitions when Lucy fired its main engines.

On 3 February 2024, Lucy conducted a 36-minute engine burn, using up (as planned) about half of its fuel to change its trajectory. It worked. The team let out a sigh of relief. We are on our way to our next main-belt asteroid target, Donaldjohanson, in April 2025, and the start of our Trojan asteroid tour in 2027. Albeit with a just very slightly floppy solar panel.

Looking back: The Sky at Night

5 February 1979

On the 5 February 1979 episode of *The Sky at Night*, Patrick Moore took a look at the Messier Catalogue. French astronomer Charles Messier was born in 1730. When he was 13, the Great Comet of 1744 passed through the skies and remained visible to the naked eye for several months. The event gave Messier a lifelong love of comets and fuelled a desire to pursue astronomy. He eventually rose to the position of chief astronomer at the Marine Observatory in Paris, where he was given the freedom to chase down comets, earning himself the nickname 'the comet ferret'.



▲ Charles Messier (1730–1817), the 'comet ferret' behind the catalogue

One night, Messier noticed a fuzzy cloud in the constellation of Taurus that he thought might be a comet. However, he soon realised the object wasn't moving against the background sky. Not wanting other astronomers to be similarly distracted, he noted the position of the object and others like it, creating a catalogue of 'things to avoid' when searching for comets. He and his assistant, Pierre Méchain, eventually created a catalogue of 103 objects, with a further seven added later, based on Messier and Méchain's notes.

As astronomical equipment improved over the years, astronomers got a more detailed look at Messier's 'fuzzy clouds', revealing them to be a plethora of nebulae, galaxies and star clusters. The first of these objects, Messier 1 or M1, is now better known as the Crab Nebula. The Messier Catalogue now stands as one of the greatest collections of deep-sky astronomical targets in the Northern Hemisphere's night sky.

The Sky at Night

Dive into the Universe with BBC Ideas

The Sky at Night TV show is currently off the air until spring, but the BBC has plenty of other ways for you to get your dose of space facts. If you prefer your view of the Universe to come in short, easily digestible chunks, check out the array of animated short films about space available on BBC Ideas. With topics ranging from the mysteries of the Moon, and the future of space exploration – including whether humans could have babies in space – to how big our Universe is, you're sure to find something you enjoy. Find the full collection at **bbc.in/4fg8yN1**.

▲ 'Should kids be in space?' is one of the questions pondered in BBC Ideas short films

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MESSAGE OF THE MONTH

Solace of the starry skies

▲ **Some of Stuart's recent shots taken with the Seestar smart scope that – along with family and astro friends – has helped him through**

Thank you for your article 'Stargazing to help your mental health' (May 2024), which struck home.

I've loved the night sky since childhood and have always had telescopes. For some years, I was a carer for my disabled wife, Paula, and we could both enjoy the views together. She encouraged me to join Bridgend Astronomical Society in south Wales. When we lost our son suddenly, it hit us both. Astronomy became a lifeline for us.

September 2023 changed all that – Paula passed away. Towards the end of her life, I purchased an ASiair astrophoto controller so she could still experience the views from indoors. The last image of the sky she got to see was a video of the August supermoon, which I filmed for our 40th wedding anniversary.

We'd been married since we were 18; I felt my life was over. But my daughters reached out to the astronomy society chairman, who came and took me to their meeting. That evening, I overheard a conversation about a Seestar scope and when I got home I made the purchase. The first time I used it, I realised how happy my wife would have been if she could see what I was seeing. Now I go to the club's meetings and have even gone out on outreach with them. Their support has been second to none. The Seestar has truly been a lifesaver, and with the support of my daughters and the group, I feel I can still enjoy doing the things I like.

Stuart Little, via email

Thank you for sharing your story with us, Stuart. We're so pleased to hear you're able to find joy in life once again. It reminds us all why we keep looking up. – ***Ed.***

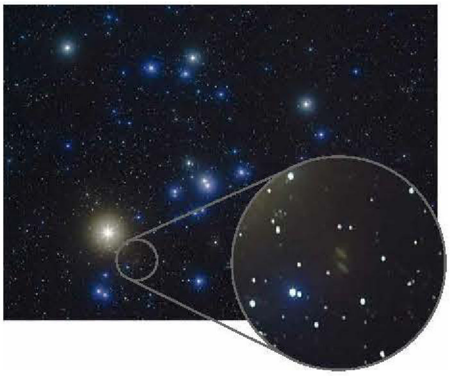
Tweet

Adam Farnell

@AdamFarnell30 • 24 November

M33 Triangulum Galaxy taken from my garden in Tarleton on 07/09/2024. 90x 120" exposures. #M33 #triangulumgalaxy @skyatnightmag

ALAN DYER/STOCKTREK IMAGES/GETTY IMAGES



◀ **Eagle-eyed Neil spotted an unexpected object in our photo of the Hyades**

Cluster crasher

In your photo of the Hyades cluster ('The glittering lights of midwinter', December 2024 issue), just below Aldebaran it looks like there's a faint, very distant pair of background galaxies. Is it real or a flaw? I've never heard of any faint galaxies in that place before.

Neil Shuttlewood, Essex

Well spotted, Neil! That looks to us like a lens flare from Aldebaran's light, not some background galaxies. – ***Ed.***

Space cowboy

The instant I viewed the nebulous formation in 'Eye on the Sky', December 2024 (R Aquarii, over the page), I saw a long-faced cowboy with a high-peaked, wide-brimmed Stetson hat! Look closely ▶

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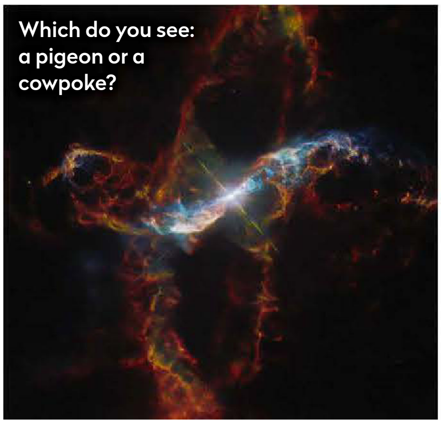
NASA/ESA/MATTHIAS STUTE/MARGARITA KAROVSKA/DAVIDE DE MARTIN (ESA/HUBBLE) MAHDI ZAMANI (ESA/HUBBLE)

▶ and you will be looking at the Cowboy Nebula in Virgo... that's the name I've come up with. And I would know, because I'm a native Texan! Yeehaw!

Robert McSpadden, Wolfforth, Texas

We saw the cowboy in the nebula instantly, Robert, and we much prefer your name to the one we suggested, the Wood Pigeon Nebula! ***– Ed.***

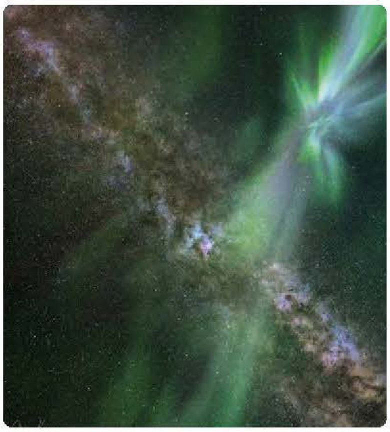


Which do you see: a pigeon or a cowpoke?

Instagram

a.kohler_photo • 23 November

Astrophotography in Sweden often comes with unexpected treasures – like the Northern Lights stealing the show! While capturing the Milky Way, I was treated to a breathtaking display: a corona aurora perfectly placed next to our Galaxy. @bbcskyatnightmag



Lunar mover?

As the Moon is moving away from the Earth due to the tidal bulge, is it pulling us along with it and, if so, in which direction? Are we moving away from the Sun? Could the Moon pull Earth out of the expansion zone of the Sun as it turns into a red giant?

Sam Burrell, via email

Good questions, Sam! The Moon is 81 times less massive than Earth, and while its gravity causes the tides, it's nowhere near strong enough to alter our position. Earth's orbit *is* getting further from the Sun, but by about 1.5cm a year – not fast enough to take it out of the Sun's expansion zone when it becomes a red giant star in five billion years. ***– Ed.***

SOCIETY IN FOCUS

Tucson Amateur Astronomy Association (TAAA) is an 800-plus member group based in Tucson, Arizona. Founded in 1954, we have strong support from the local astronomy community: the University of Arizona, Kitt Peak National Observatory, Mount Lemmon Observatory, the Lunar and Planetary Lab and the Mirror Lab. Our past presidents have been David Levy, Tim Hunter and Dean Ketelsen.

We hold monthly meetings at the University of Arizona Steward Observatory, providing recent research results as well as information for observers of all levels. Educational and imaging subgroup meetings and observing opportunities are held monthly at our two dark-sky sites, as well as other locations.

We have an extensive outreach programme too, holding up to 25 star parties a month in peak season at national parks, state parks, county parks and on school grounds in and around Tucson, as well as supporting check-out telescopes at local libraries.

TAAA's enviably remote TIMPA site, complete with pier-mounted telescopes

Our TIMPA dark-sky observing site is west of the city and has two pier-mounted scopes: a Meade 16-inch and a Celestron 14-inch, as well as six cement pads with AC mains power.

Our east site, Chiricahua Astronomy Complex, is located in a valley between mountain ranges 100 miles away, with Bortle 1 skies. We have several pier-mounted scopes: a 40-inch Dobsonian, a 9-inch refractor, various Schmidt–Cassegrains, 20 pads and a warm room, as well as a classroom. In addition, it offers sleeping rooms for members and educational groups.

Bernie Stinger, TAAA star party manager

▶ www.tucsonastronomy.org

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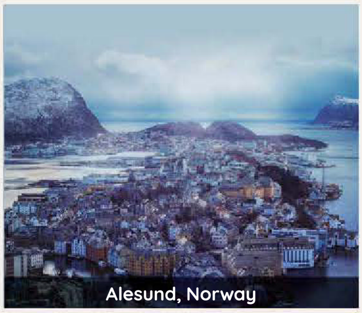
Alesund, Norway

Day	Port	Country	Arrive	Depart	Stay
1	London Tilbury	UK	-	17:00	
2	Ijmuiden, for Amsterdam	Netherlands	09:00	15:00	6h
3	At Sea		-	-	
4	Alesund	Norway	12:00	19:00	7h
5	At Sea		-	-	
6	Tromso	Norway	12:00	22:00	10h
7	Alta	Norway	09:00	-	
8	Alta	Norway	-	19:00	34h
9	At Sea		-	-	
10	Narvik	Norway	08:00	18:00	10h
11	Bodo	Norway	07:00	16:00	9h
12	At Sea		-	-	
13	Bergen	Norway	08:00	16:00	8h
14	At Sea		-	-	
15	London Tilbury	UK	08:00		

	Twin Cabins		Single Cabins	
	Inside fr.	Ocean View fr	Inside fr	Ocean View fr
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Tromso, Norway

Day	Port	Country	Arrive	Depart	Stay
1	London Tilbury	UK	-	17:00	
3	Haugesund	Norway	09:00	18:00	9h
4	Bergen	Norway	09:00	18:00	9h
6	Alesund	Norway	08:00	18:00	10h
7	Trondheim	Norway	08:00	17:00	9h
9	Tromso	Norway	08:00	18:00	10h
10	Alta	Norway	08:00	-	
11	Alta	Norway	-	12:00	28h
13	Leknes, Lofoten Islands ⚓	Norway	08:00	18:00	10h
14	Bodo	Norway	08:00	13:00	5h
16	Aberdeen	Scotland	13:00	20:00	7h
18	London Tilbury	UK	08:00		

Days not shown are spent relaxing at sea. ⚓ Land by launch or tender.

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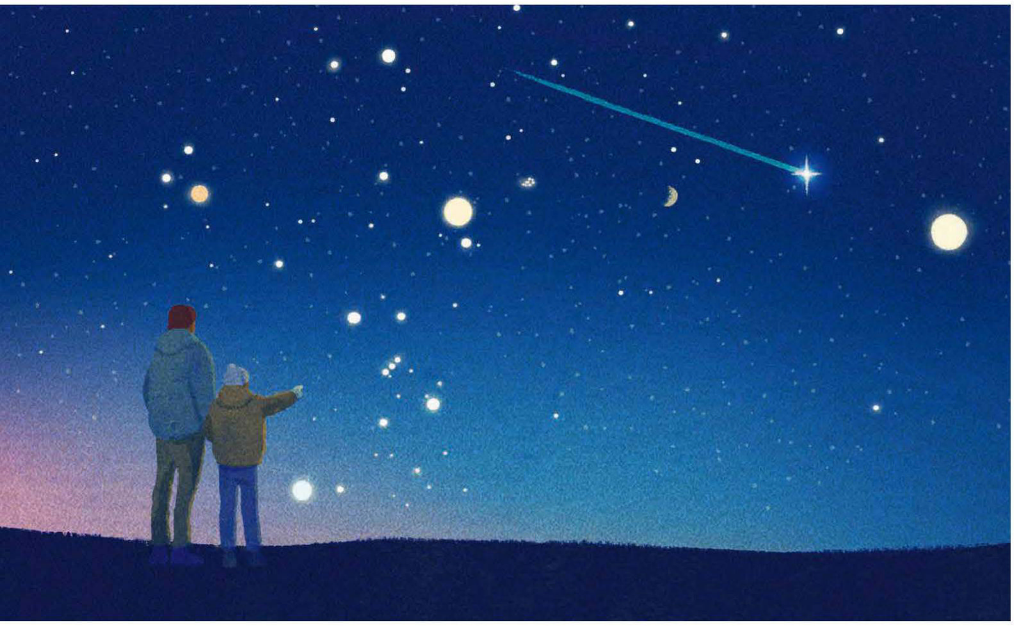
FIELD OF VIEW

Seeing in a new light

It's National Astronomy Week this month, so take a tip from **Mark Westmoquette** and let mindful stargazing change your perspective on your life and problems



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Back in 2008, when I was working as a professional astronomer, I was granted two nights on a big telescope on Mauna Kea, Hawaii. I remember arriving at the summit of the volcano at dusk, very excited about this incredible opportunity. I went into the brightly lit telescope control room, plugged in my laptop and started preparing for the night of taking data. When it was dawn, I emerged into the sunrise, bleary eyed and ready for dinner… or was it breakfast?

It was only years later that I realised I'd been to the summit of Mauna Kea and I hadn't looked up at the night sky with my eyes even once. I now see this lamentable situation was representative of a deeper state of mental difficulty that had crept up on me like a long, slow sunset.

Over my years of immersion in the academic environment, I'd become lost in the world of ideas, disconnected from an emotional, direct experience, and from the wonder and passion that had drawn me into astronomy in the first place.

I've come to understand that this situation isn't unique to me. These are typical symptoms of the modern world. So many of us live increasingly disconnected from nature – in the day and nighttime – often lost in the world of ideas, plans or anxieties, with our attention rarely in the here and now.

Astrophysics was what led me into the disembodied world of ideas and facts, but it was ultimately stargazing in a mindful way that showed me the way back to a more balanced state of mental wellbeing and the wonder of my subjective, very human perspective.

What I've come to call 'mindful stargazing' is the act of looking at the stars in a curious, open-minded and open-eyed way, not driven by technology or by a quest for the facts and figures. When we immerse ourselves in our present-moment experience, not just of looking at the stars, but also sensing the sounds, smells and feelings of the nighttime, it encourages the whirlwind of thoughts to gradually recede.

When we look with wide-eyed curiosity, rather than being crammed with facts and expectations, it encourages a state of wonder, the precursor of awe. Studies have shown feeling awe on a regular basis is deeply beneficial to our mental health, because it helps us feel connected to something bigger than our everyday view of ourselves. Suddenly, our worries aren't quite so all-important and we start to see ourselves from a different perspective.

It's so easy to think that we're looking up *at* the stars. But the truth is we're *in* them – made of them, inseparable from them. You have grown out of, and are living as part of, this Universe. True, looking at it one way you're a tiny, seemingly insignificant dust mote on a remote planet in an unremarkable solar system. But from another perspective, you're an integral part of the Universe experiencing itself through your own eyes, ears and thoughts. For me, this view has catalysed a complete transformation of my mental health and whole life.

▶ Reconnect with the night sky on National Astronomy Week, 1–9 February, **www.astronomyweek.org.uk**

Author of *The Mindful Universe*, astronomer and mindfulness teacher **Mark Westmoquette** lives in London with his young family

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News

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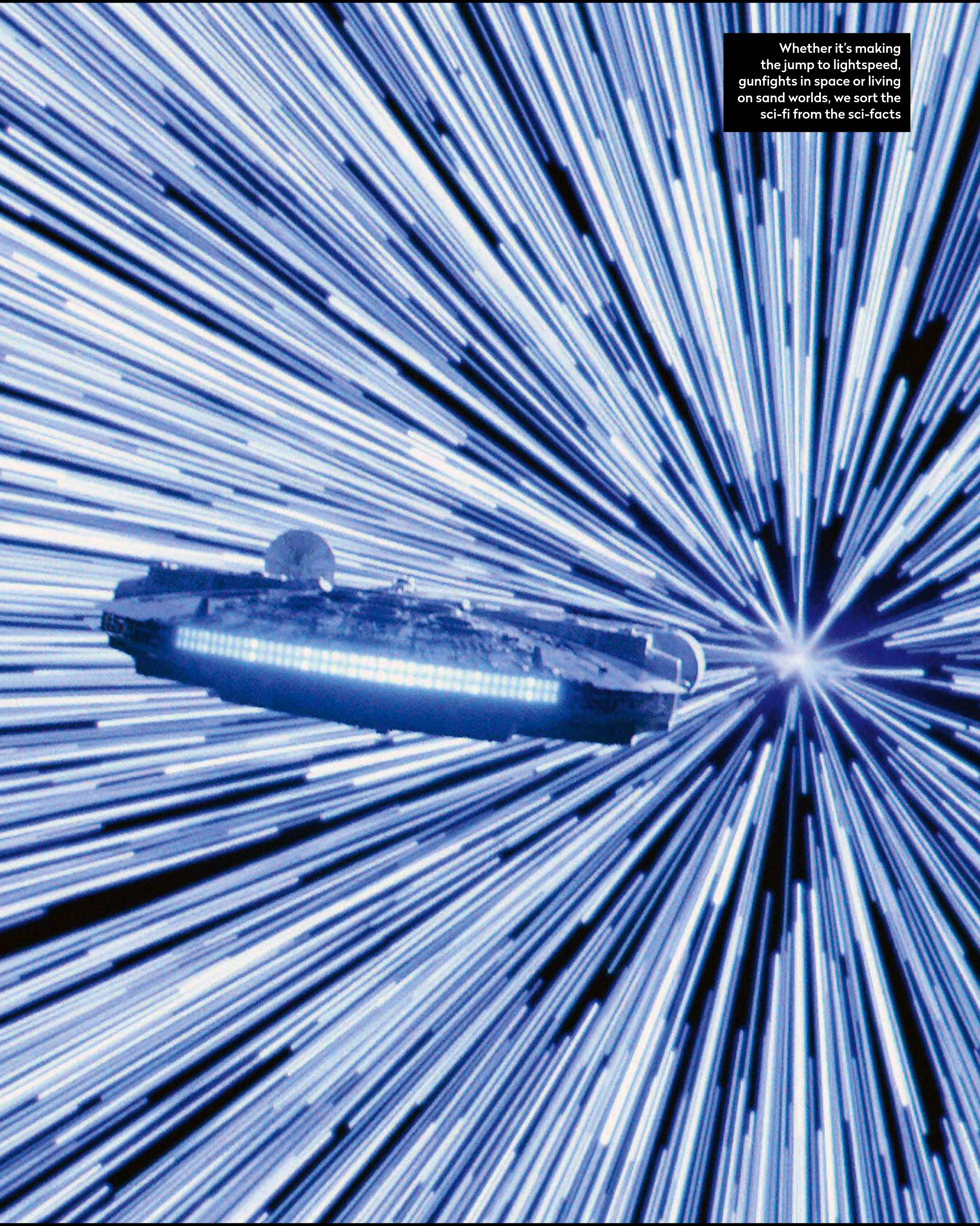
The science of SCI-FI

We love a good sci-fi film, but do they get the science right? **Amy Arthur** picks six of the big mistakes made in space films

Hollywood's greatest sci-fi blockbusters have taken us to the stars, introduced alien worlds and imagined humanity's future in the cosmos. But how often do they get the science right? In the rush to thrill and entertain, filmmakers often sacrifice realism for dramatic effect. From explosive sound in the vacuum of space to impossibly fast interstellar travel, these cinematic liberties stretch – and sometimes break – the boundaries of actual science.

Here we take a look at six common mistakes that Hollywood makes about space science, unravelling the truth behind the fiction. What would really happen if there was a fire in space? Is warp speed actually possible? And could you have a punch-up in zero gravity? Get ready for science to set the record straight, proving that reality can be just as fascinating as fiction. ▶



Whether it's making the jump to lightspeed, gunfights in space or living on sand worlds, we sort the sci-fi from the sci-facts

Fire in microgravity

Flames in space shouldn't behave like they do at home

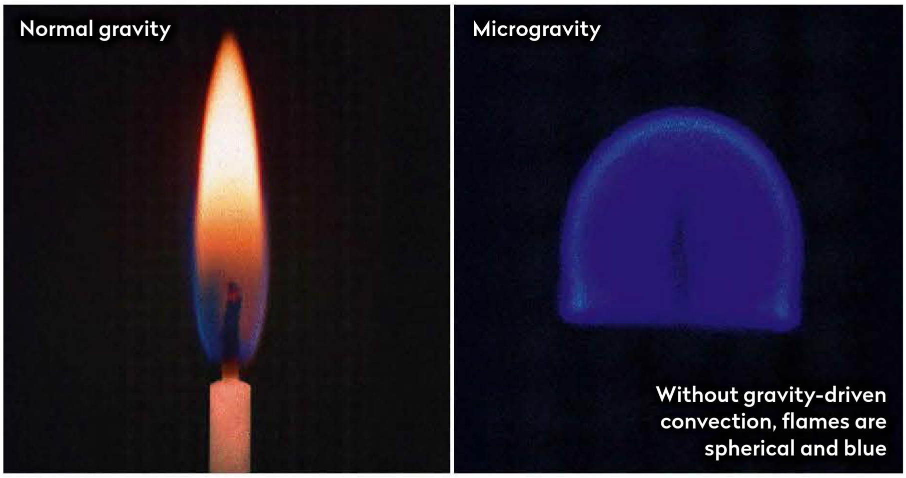
Gravity's Dr Ryan Stone, presumably wondering if a space lab inferno really would have long, yellow flames

Fire can't start in the vacuum of space, as there is no oxygen available for combustion. They can, however, start inside a spacecraft or space station that has oxygenated air for passengers. Any fire in space would look and behave differently than the lit candles on your birthday cake back at home, though, and that's down to gravity.

The typical teardrop shape of a burning candle on Earth is caused by the effects of gravity: hotter air is less dense, so it rises to the top of a flame in a peak. This also pulls in cooler, more oxygenated air, keeping the fire going.

But in microgravity, the hot air forms a spherical shape around the source of the fire. This limits how hot the fire can get and how long it can burn, as there are no convection currents to supply the flame with fresh oxygen for combustion. The fire will also likely be stifled by its own exhaust gases, limiting its lifespan.

So, that pivotal scene in the film *Gravity* where Sandra Bullock's character battles a roaring fire on board the International Space Station? Pure fiction. She attempts to put the fire out with a CO_2 fire extinguisher, which may actually work, provided it was one designed for a microgravity environment.



Without gravity-driven convection, flames are spherical and blue

PICTURELUX/THE HOLLYWOOD ARCHIVE/ALAMY STOCK PHOTO, NASA, DESIGNPROJECTS/GETTY, FLIXPIX/ALAMY STOCK PHOTO, NASA/JPL-CALTECH, NASA GODDARD SPACE FLIGHT CENTER, MUNHEE CHOI/GETTY

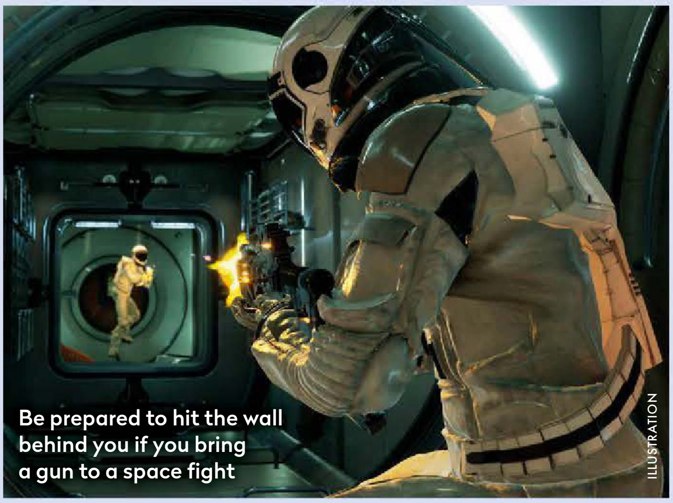
Zero-G fight club

How would a head-to-head scuffle really play out in a weightless environment?

There have been some memorable fight scenes in space over the years, but how many of them are an accurate representation of how the struggle would play out in microgravity?

Let's look first at one-on-one combat. We don't see many fights between individuals wearing bulky spacesuits, which makes sense, given they would hinder movement. It probably wouldn't make for a very engaging action scene. So, we'll assume we're talking about a fight inside, where the air is oxygenated.

Momentum would be the third opponent in any fist fight. Newton's laws dictate that for every action there is an equal and opposite reaction. Down on Earth, punching someone would exert a force on them but also on you, though we can brace ourselves against the ground. In microgravity, however, the punch would send us backwards. We could use this to our advantage: pushing against a wall to give our attack even greater force.



Be prepared to hit the wall behind you if you bring a gun to a space fight

If you're bringing guns into this space fight, you'll get the same problem. The recoil would start you moving in the opposite direction at the speed of a few centimetres per second (though not enough to make Colin Farrell's escape in the 2012 version of *Total Recall* realistic).

What about fights between spaceships? Guns and lasers would both work, though they too would exert an equal and opposite force on your own ship. To remain stationary, you'd need to put some thrusters on. Disappointingly, there would be no 'pew! pew!' sound because, of course, there's no sound in space.

Dune's Arrakis is an unremittingly hot landscape of rainless deserts – and sandworms

Mono-biome planets

Snow planets and forest worlds abound in sci-fi, but could life really get a foothold?

If there's one thing sci-fi writers love, it's a single-biome planet. There's the water world Kamino in *Star Wars*, desert planets like Arrakis from *Dune* and the forest planet Kashyyyk that's home to the Wookie species. Unlike Earth, which is made up of different biomes, these planets are characterised by their homogeneity. Their landscapes can resemble other planets known to exist, like the arid, cold deserts of Mars, the 'ice planets' Uranus and Neptune, and the hellishly hot, volcanic world Venus, cloaked in clouds of sulphuric acid.

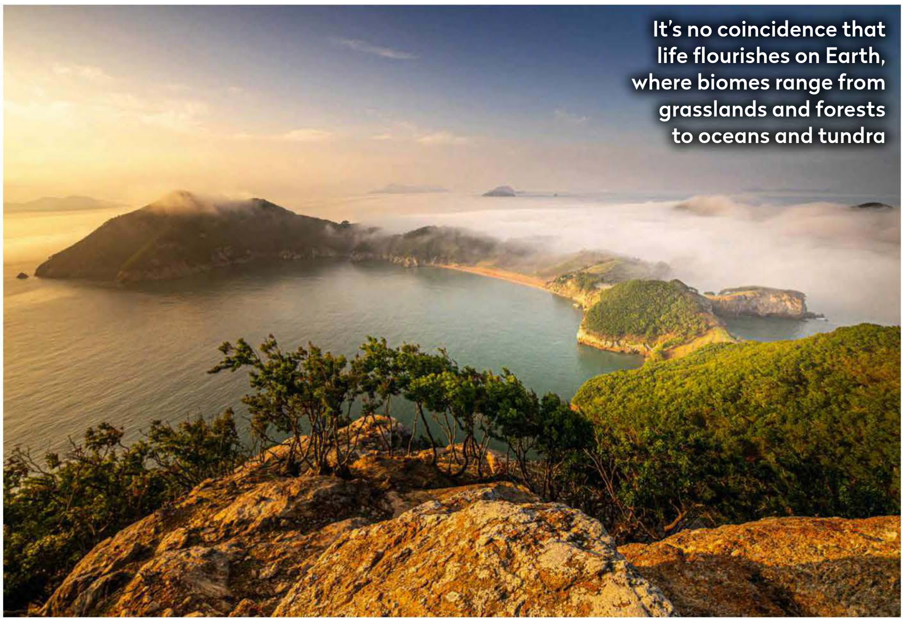
Of course, there is no evidence yet of life on any of the other planets in our Solar System. It's likely that this is exactly why there is such consistency in their landscape, because the evolution of life here on Earth has impacted the geology of the planet.

We know that humans are today affecting Earth's climate and composition, but even the very first microorganisms had a part to play in shaping the world. Early microbial life is linked to the oxygenation of our atmosphere and our oceans.

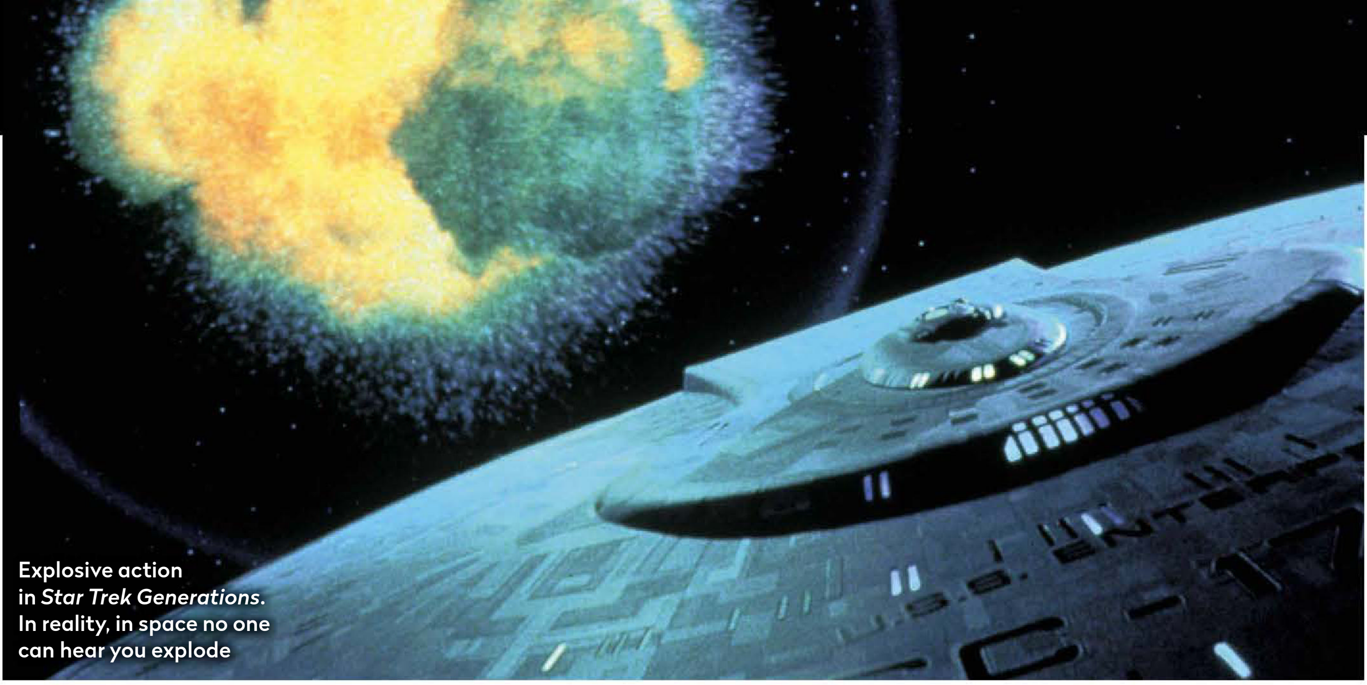
If life leads to the creation of several biomes within one planet, then we would expect to see more complexity in the inhabited planets of our favourite science fiction. Worlds where life is only just emerging may be less diverse at their surface, but when intelligent lifeforms have evolved, the possibility of a single-biome planet seems very unlikely. ▶

Countless sci-fi stories have taken arid Mars as an inspiration

A hellish planet like Venus in reality leaves little room for life



It's no coincidence that life flourishes on Earth, where biomes range from grasslands and forests to oceans and tundra



Explosive action in *Star Trek Generations*. In reality, in space no one can hear you explode

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Explosions in space

A classic, climactic sci-fi trope, these big blasts would look rather different in real life

Most great sci-fi explosions are accompanied by an almighty 'ka-boom!', but you already know that this is only possible in Hollywood space. In reality, an explosion in space would be deathly silent.

On Earth, the most damaging part of an explosion is the shock wave it creates in the air. This is when the chemical reaction that makes an explosive material explode creates a highly pressurised, hot gas that expands rapidly, travelling outward from the explosion as a wave of destruction. The shock wave is carried by the particles in the air and will keep going until it loses its energy, giving us the blast radius.

But in outer space, there are very few particles. The initial explosion will still involve a high-pressure gas at high temperature, but there won't be any atmosphere to carry the shock wave. This means an explosion in space won't be as destructive as it would be on Earth. The target would still explode, sending shrapnel out into space on a trajectory that could, in theory, go on forever if nothing stood in its way.

With no oxygen in space, an explosion wouldn't produce a roaring fire. It could ignite the oxygen inside a spaceship, though, so there would be some flames in certain circumstances.

While the detonation of the spaceship Nostromo at the end of Ridley Scott's *Alien*, or the huge explosions during space battles in *Star Trek* are spectacularly unrealistic, 2014's *Interstellar* is a good example of a movie getting an explosion in space nearly right. The scene occurs in complete silence, and fire appears only where oxygen is escaping from the exploding ship.

Dangerously dense asteroid fields

Is the asteroid belt really dangerous? Just ask the NASA probes that have been there

Han Solo didn't like the odds, but chances are you'd sail through asteroids unscathed

Whether you're in a doomsday film or flying a spaceship in deep space, you'll likely encounter the dangers of a densely packed asteroid field at some point in your sci-fi story. Huge rocks tumbling towards you, leaving little room to manoeuvre, make them an extremely dangerous place to be. As C-3PO remarks in *The Empire Strikes Back*, "the possibility of successfully navigating an asteroid field is approximately 3,720 to 1".

In reality, the distance between individual asteroids is huge. The main asteroid belt found in our Solar System lies between the orbits of Mars and Jupiter, and the average distance between individual asteroids is just under 1 million kilometres (621,370 miles). That's 24 times the circumference of Earth, so if Han Solo can't navigate it, maybe he shouldn't be flying.

A number of spacecraft have safely and successfully travelled through the asteroid belt. NASA's New Horizons passed through on its way to Pluto back in 2006, while the Lucy spacecraft, launched in 2021, completed a fly-by of the small main-belt asteroid Dinkinesh in 2023.

We've discovered what appear to be asteroid belts in other star systems and there are likely more to be found, though it's highly unlikely that any of them are as tightly packed as shown in the movies. If they were, the asteroids would be constantly colliding with one another, breaking up into pieces and eventually being ground down to dust.

The ship in *Event Horizon* handily solves the problem of vast cosmic distances by folding spacetime

Faster-than-light travel

Warp speed gives our sci-fi heroes free reign of the cosmos. This is what physics says

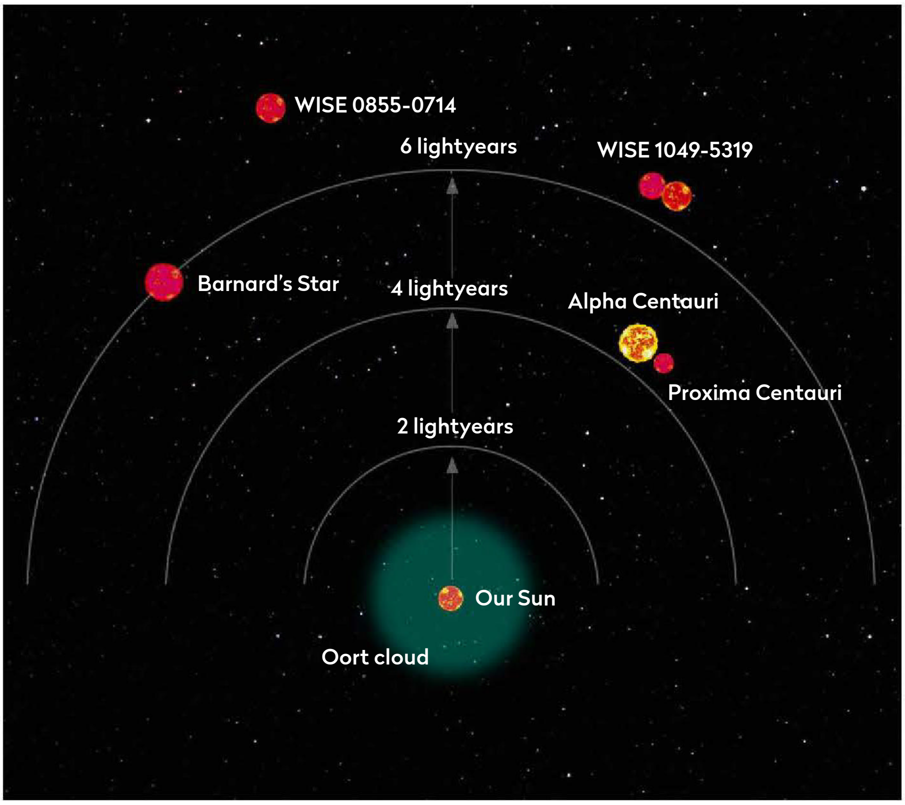
Space is... big. Any story that involves characters traversing it needs to come up with a way to address the vast distances between galaxies. There are a few ways that sci-fi writers get around this problem of moving their protagonists from one point in space to another, including teleportation, wormholes and faster-than-light travel.

Travelling at the speed of light – around 300,000km (186,000 miles) per second – would allow you to circumnavigate Earth 7.5 times in a single second and get you to the surface of the Sun in a little over 8 minutes. But if you wanted to visit Earth's nearest neighbouring star system, Alpha Centauri, some 40,000 billion kilometres away, your journey would take just under 4 years and 3 months. If faster-than-light travel was an option, though, you could explore the whole Universe.

Unfortunately, not only is it impossible for anything to go faster than the speed of light, but according to Einstein's special theory of relativity only things with zero mass at rest (like photons) can travel at the speed of light. Things with mass, like us and spaceships, will always have to travel at subluminal speeds.

There are ways in which science-fiction writers have attempted to explain away faster-than-light travel, however. The 1997 movie *Event Horizon* explores the idea that a spacecraft might effectively travel faster than light by folding the fabric of space on itself, thereby creating a means of travelling across the Universe in an instant.

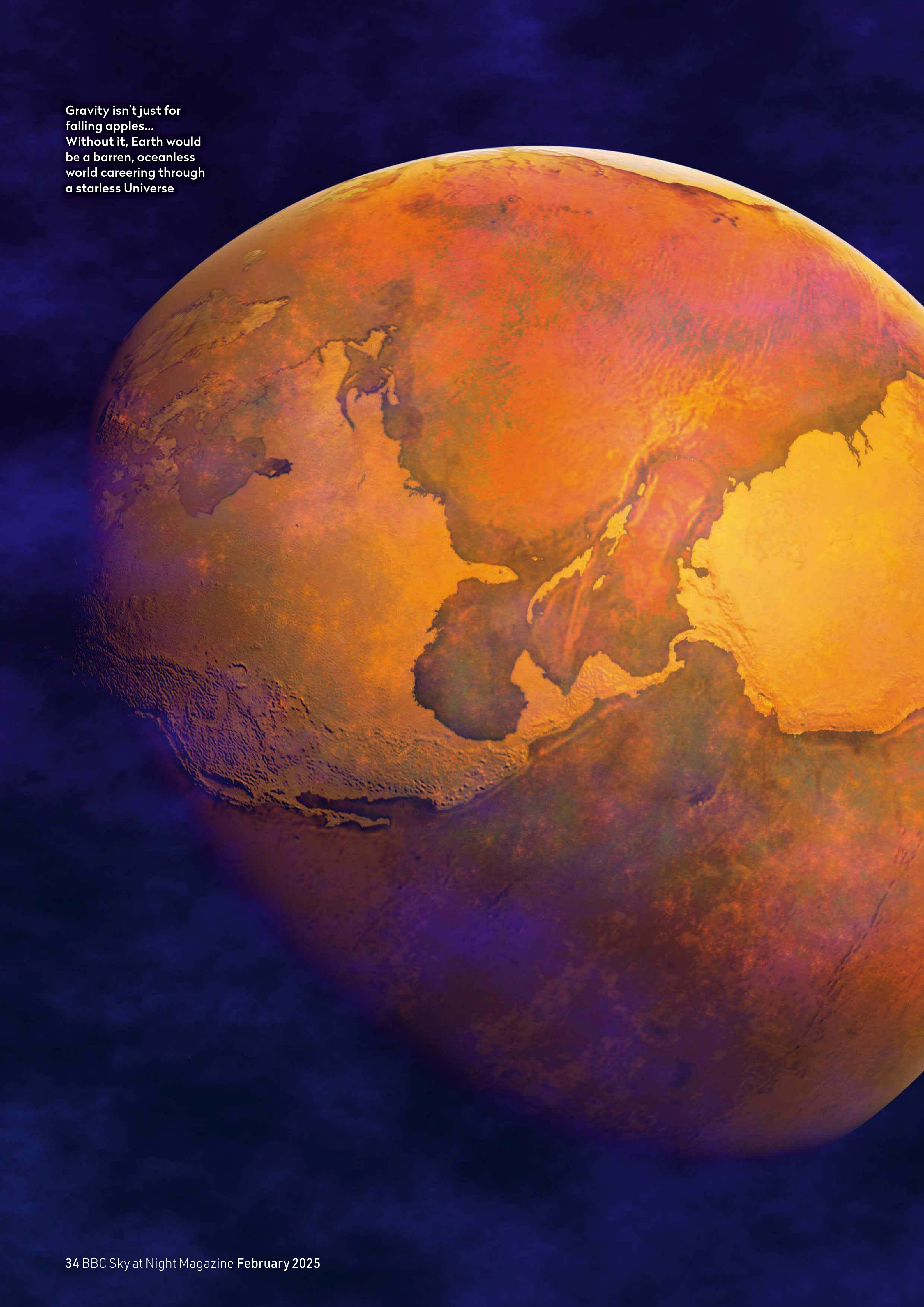
Interestingly, it's possible that the speed of light hasn't always been constant. Observations suggest that there were different wavelengths of light billions of years ago, and some have even postulated that this could support the notion of extra space dimensions where the laws of physics are different. Maybe, then, we could one day enter the hyperspace dimension to visit a galaxy far, far away...



▲ The four nearest stars to our Sun. Even at lightspeed, it would take 4.2 long years to reach our closest neighbour, Proxima Centauri – which doesn't exactly make for riveting drama

Amy Arthur is an author, podcaster and speaker who specialises in science and mental health

Gravity isn't just for falling apples... Without it, Earth would be a barren, oceanless world careering through a starless Universe



The Universe without gravity

Life with no gravity might sound a fun idea, but as **Govert Schilling** explains, shutting off this pivotal force would spell disaster for Earth and beyond

Gravity is a nuisance, don't you think? The gravity of our home planet makes it hard to climb a mountain. It can cause a broken leg if you fall down the stairs. It makes you very much aware of your body mass. And it's the main reason why pigs – or people – don't fly.

Wouldn't it be great to experience no gravity? To effortlessly float around in any direction you wish, like astronauts on board the International Space Station? You wouldn't need stairs anymore, or elevators, for that matter. Then again, as every astronaut can tell you, drinking a cup of coffee would become quite a challenge.

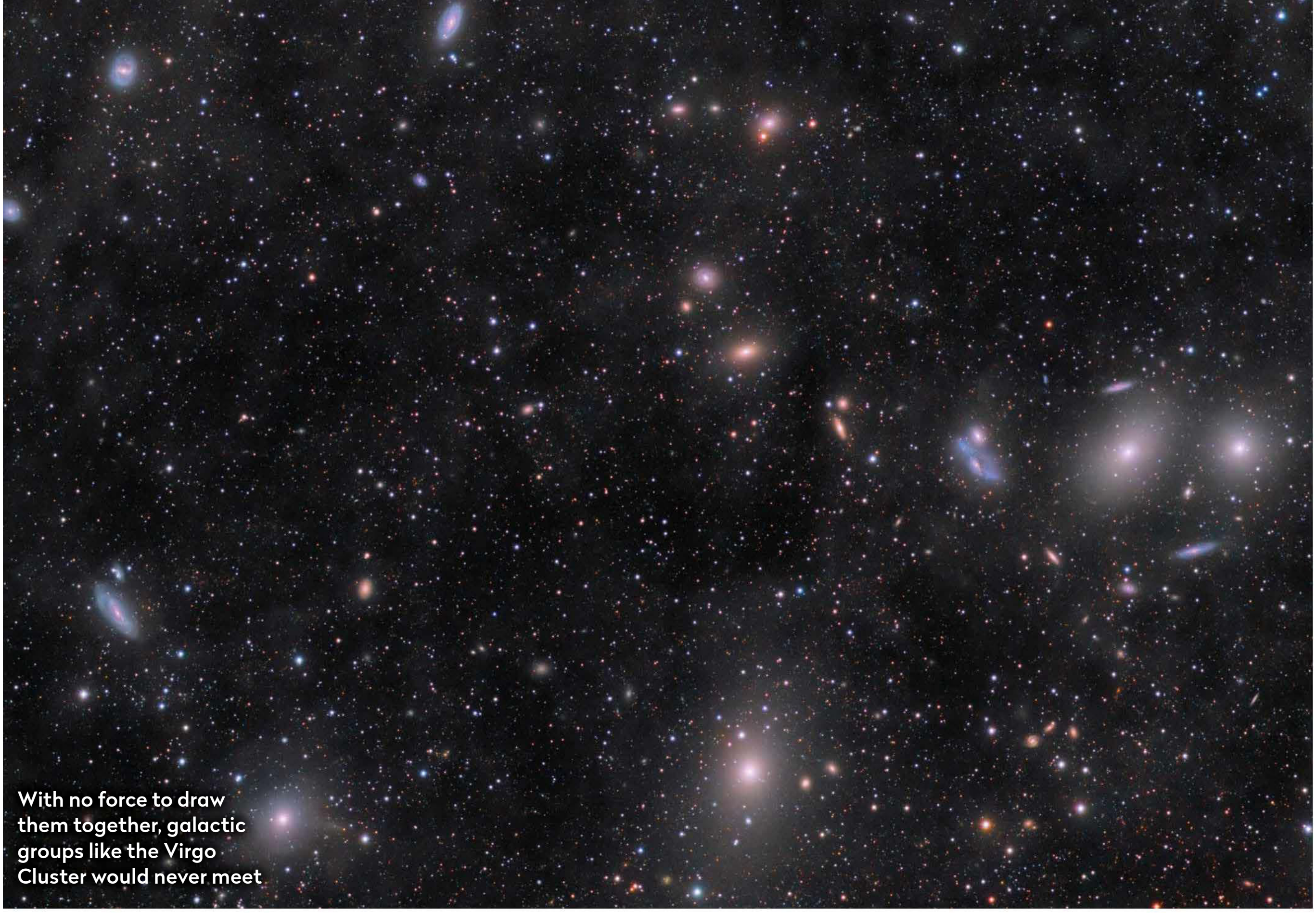
But it's an interesting thought experiment. What would the world, and indeed the Universe, look like if there were no gravity, if we could shut it off completely, or if it had never existed at all?

For one, life on our planet would have been completely different. In a world with no gravity, there's no need for the evolution of wings. Legs aren't really necessary either. And animals could be much larger than blue whales or dinosaurs, as weight no longer puts constraints on body size.

But wait a moment. Life would have a very difficult time existing in the first place, as Earth would have no atmosphere. Only through gravity is our planet capable of retaining that thin layer of breathable gases. Without gravity, the atmosphere – and the oceans, for that matter – would escape into space, and the third rock from the Sun would be as barren as low-mass worlds like the Moon and Mercury.

And there's another disastrous consequence of shutting off gravity. It's the gravitational attraction of the Sun that keeps our planet in orbit around it, completing one 940-million-km (584-million-mile) loop in one year. If someone were to suddenly flip the G-switch, Earth would fly off into space along a straight line, with its instantaneous velocity of 29.8 km/s (66,660mph). Not a good prospect. ▶

EARTH ILLUSTRATION: MARK GARLICK/SCIENCE PHOTO LIBRARY/GETTY, BACKGROUND: TETIANA TANASIICHUK/GETTY



With no force to draw them together, galactic groups like the Virgo Cluster would never meet

▶ There probably are planets wandering through empty space, having been kicked out of their planetary systems one way or the other, but without the cherishing light and heat of a nearby Sun, it's hard to see how such rogue worlds could sustain life.

In fact, the whole concept of orbits would cease to exist if there were no gravity. No moons or ring systems orbiting planets. No planets orbiting stars. No stars orbiting the supermassive black hole in the centre of our Milky Way Galaxy. Worse: no stars to orbit around in galaxies at all. Each and every celestial body would be on its own, flying around haphazardly.

Natal attraction

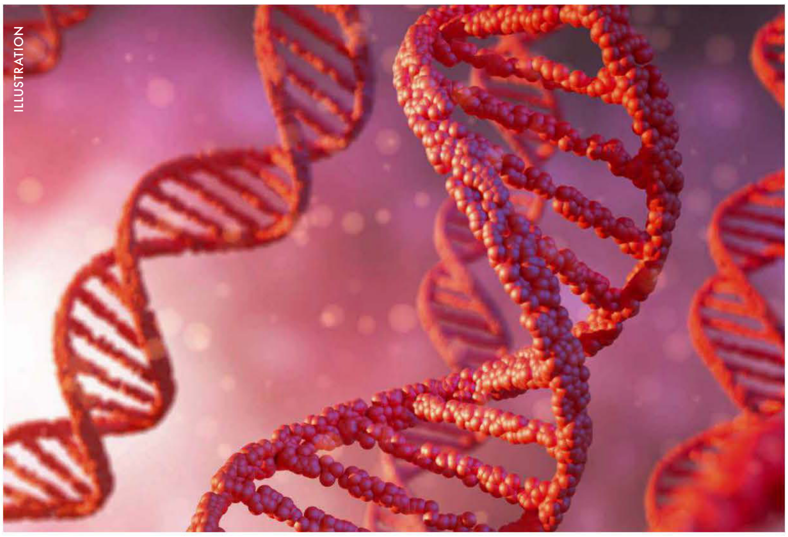
Come to think of it, the whole architecture of the Universe is shaped by gravity. Every system and structure, from the smallest binary stars to the largest supercluster of galaxies, is held together by this single force of nature. Which is quite remarkable, as gravity is by far the weakest of the four fundamental forces.

The reason why the other forces are less relevant for the large-scale structure of the cosmos is that two of them – the strong and weak nuclear force – only act across subatomic distances, while the third – electromagnetism – can both be attractive and repulsive, which means that it averages out over large distances.

Gravity, in contrast, is a long-range force that can only be attractive. Sure enough, nuclear forces are important to keep atoms together; magnetic fields play an important role in the motions of charged particles; and without electromagnetism there would be no light. But gravity, the feeblest of forces, is the great architect of the cosmos.

So would protons and neutrons still cling together to form atomic nuclei in a Universe with no gravity? Yes – their behaviour is governed by the strong nuclear force. Would molecules – from simple carbon monoxide to complex DNA – still be able to exist? Absolutely – they are held together by electromagnetic forces. But would the Andromeda Galaxy or the Virgo Cluster remain intact without the force of gravity? No way.

But there's more. Not only does gravity allow the existence of structure in the Universe at almost every



ILLUSTRATION

▲ **DNA could survive the gravity switch-off. Minute molecules would still hold together via electromagnetism**

> ***"Every solid object in space larger than a small pebble owes its existence to gravitational attraction… Without gravity, Earth wouldn't have a Moon"***

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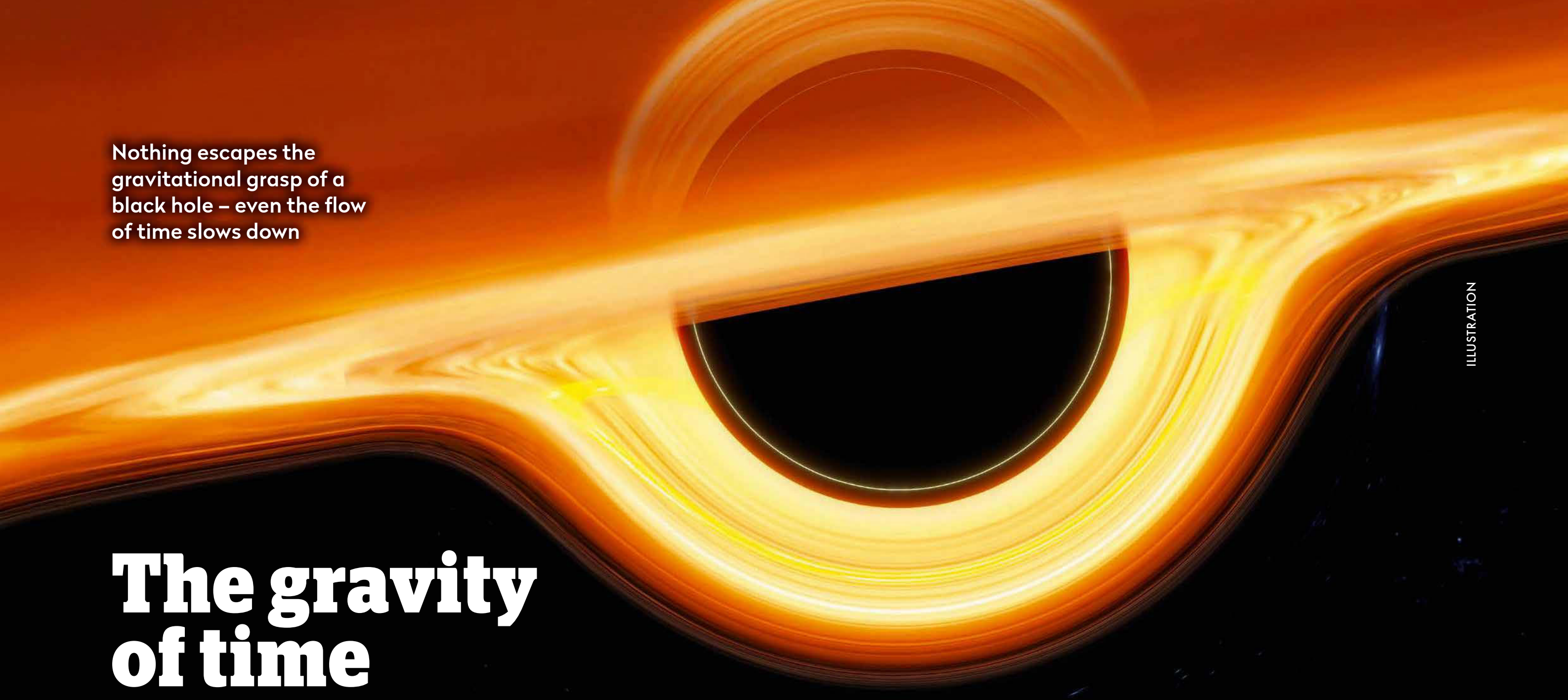


Nothing escapes the gravitational grasp of a black hole – even the flow of time slows down

ILLUSTRATION

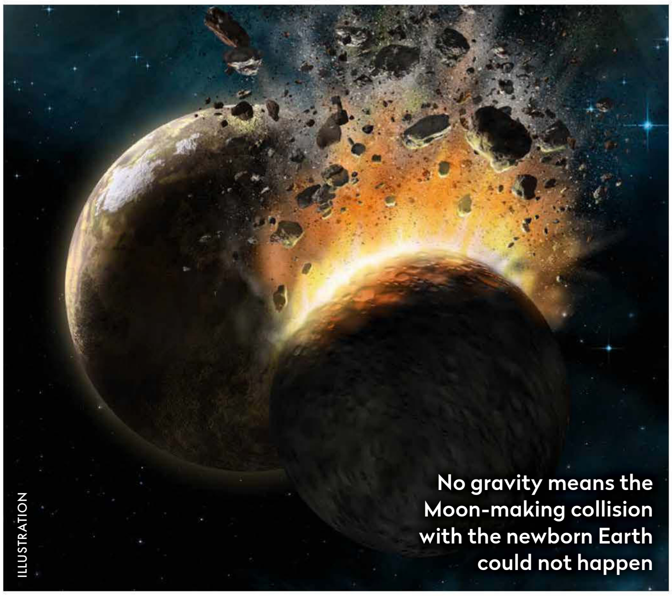
The gravity of time

Gravity is intrinsically connected with another fundamental aspect of our Universe

Gravity is a weird force. It not only acts on mass – every single particle that has mass exerts a tiny amount of gravitational attraction on every other particle – but also on space and time. In fact, according to Albert Einstein's general theory of relativity, gravity is nothing else than the slight curvature and deformation of four-dimensional spacetime, as a result of the presence of mass or energy.

One consequence of the theory (which has been confirmed over and over again) is that gravity influences the flow of time. In a strong gravitational field, time slows down, at least for an outside observer. At the edge of a black hole – its event horizon – time even comes to a complete standstill.

So if you want to live longer, you'd better buy an apartment at the top level of a 30-storey building, or build your house in the Himalayas, where the gravitational field of Earth is just a tiny bit weaker than at sea level. The differences are extremely small, of course, but atomic clocks on board GPS satellites need to be corrected for these effects, lest your navigation software sends you into a ditch.



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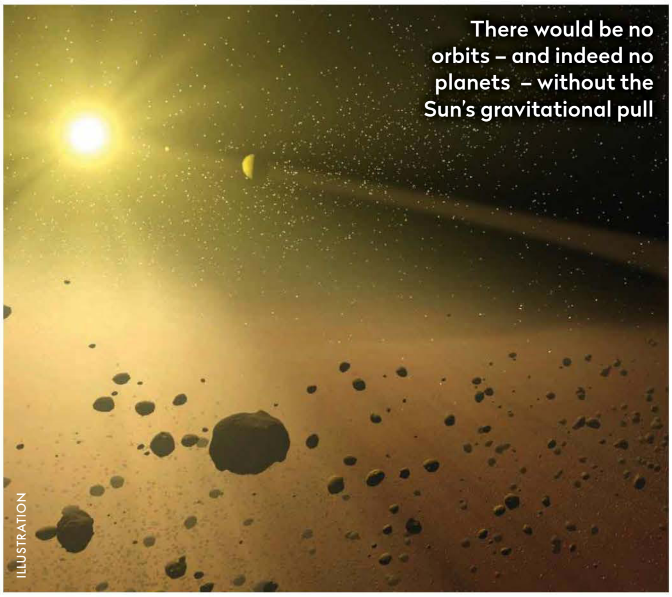
No gravity means the Moon-making collision with the newborn Earth could not happen



There would be no orbits – and indeed no planets – without the Sun's gravitational pull

ILLUSTRATION

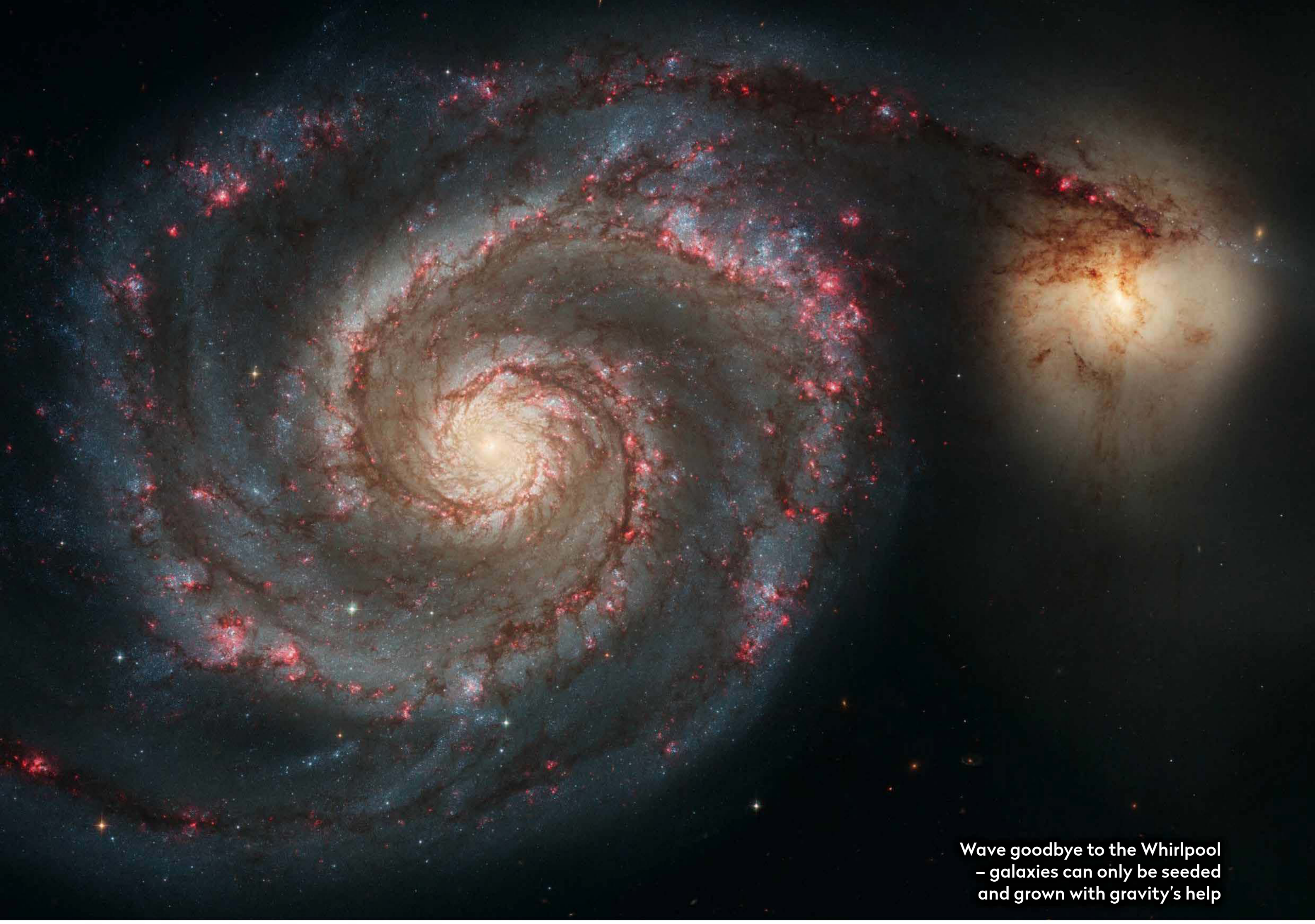
conceivable scale, it also governs the formation of each and every part of that structure. Every solid object in space larger than, say, a small pebble owes its existence to gravitational attraction.

Take the Moon, for example. According to the popular Big Splash theory, it was formed when fragments created from the collision between the newly born Earth and a small protoplanet clumped together. But without gravity, nothing would ever clump together, and Earth wouldn't have a Moon in its night sky.

Earth itself would also not exist, by the way. The planets in our Solar System accreted from gas and dust particles in the protoplanetary disc orbiting the young Sun. While molecular forces may create millimetre-sized structures, any larger clump of matter only forms through gravitational interactions.

Stars snuffed out

And what about stars? Well, these huge balls of incandescent gas form out of tenuous nebulae that contract under their own gravity. Without gravity, a cloud of hydrogen and helium gas would never collapse in on itself. And without gravity, pressures and temperatures would never rise high enough to ignite nuclear fusion. ▶



Wave goodbye to the Whirlpool – galaxies can only be seeded and grown with gravity's help

"Our Universe would be without form or structure. More importantly, it would be without much chemical variety"

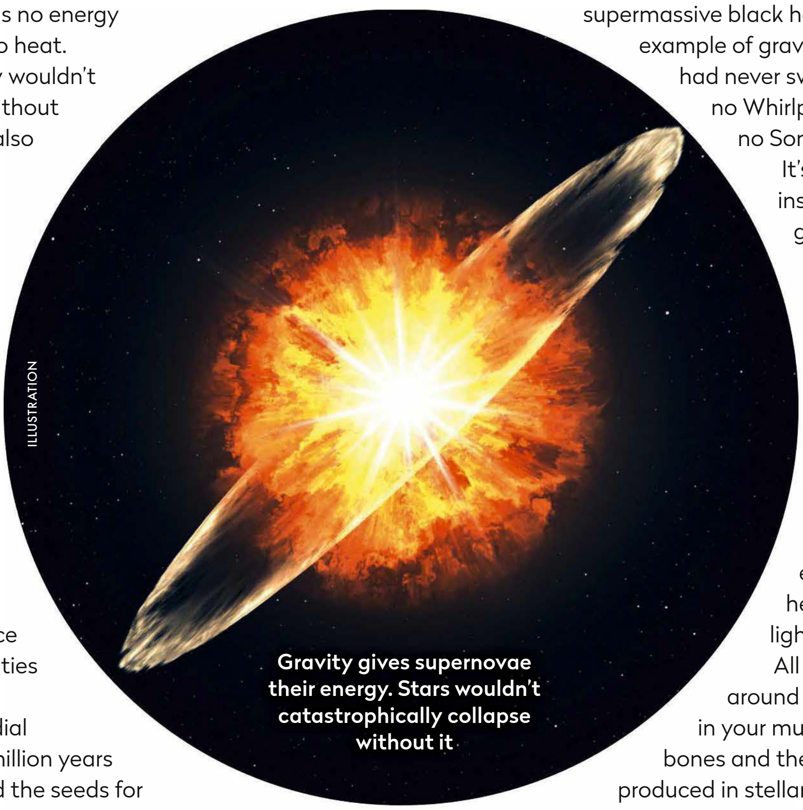
▶ No nucleur fusion means no energy production, no light and no heat. A Universe without gravity wouldn't contain stars at all. And without stars, the Universe would also lack red giants, planetary nebulae and white dwarfs (the terminal stages of low-mass stars like our own Sun), as well as supernovae, neutron stars and black holes (the end products of the evolution of massive stars).

Galaxies quashed

Even galaxies, the most majestic objects in the cosmos, owe their existence to the world-building qualities of gravity. Minute density fluctuations in the primordial soup, just a few hundred million years after the Big Bang, formed the seeds for the formation of the first galaxies and the first supermassive black holes in their cores – another example of gravitational collapse. If gravity had never switched on, there would be no Whirlpool, no Pinwheel and no Sombrero.

It's a thought-provoking insight: if there were no gravity, our Universe would be cold and dark, without form or structure. And, more importantly, it would be without much chemical variety, since the fusion reactions in the first three minutes after the Big Bang led to a Universe that, early in its history, consisted almost exclusively of hydrogen and helium, the two simplest and lightest elements.

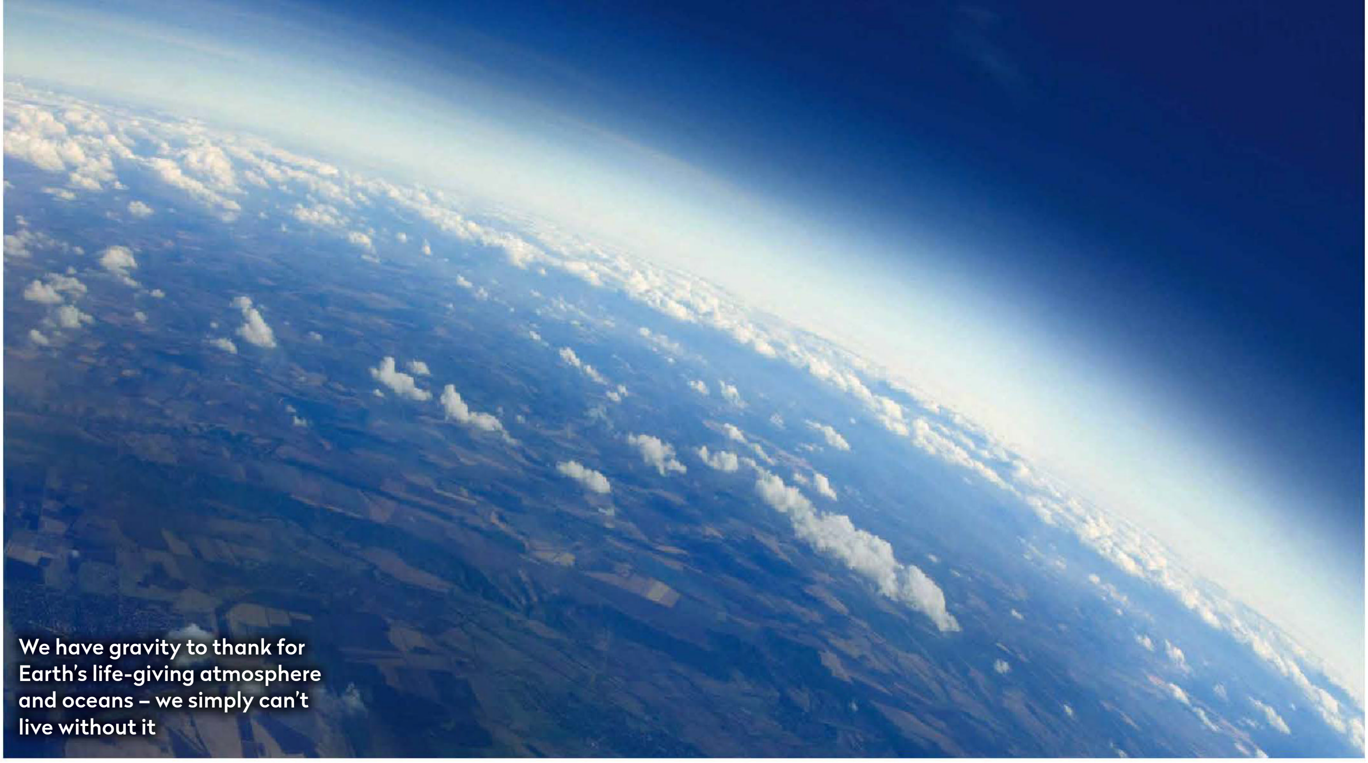
All heavier atoms in the world around you, including the carbon in your muscles, the calcium in your bones and the iron in your blood, are produced in stellar interiors, in supernova explosions or in the catastrophic collisions of



ILLUSTRATION

Gravity gives supernovae their energy. Stars wouldn't catastrophically collapse without it

NASA/ESA/S. BECKWITH (STSCI) AND THE HUBBLE HERITAGE TEAM (STSCI/AURA), MAGANN/GETTY, ALEKSANDARGEORGIEV/GETTY, ESA/HUBBLE & NASA/S. JHA



We have gravity to thank for Earth's life-giving atmosphere and oceans – we simply can't live without it

neutron stars. No gravity effectively means no chemistry, let alone life.

And what about the Universe itself? Nobody knows how the Universe was born. We don't know precisely what role gravity played in the creation of the cosmos, if any. What we do know is that the evolution of the Universe at large is a tug-of-war between the expansion of empty space (which is actually accelerating and has been for about five billion years or so) and the mutual gravitational attraction of all cosmic matter.

Expansion let loose

Without gravity, nothing would put the brakes on the expansion of the Universe, and it would live forever, growing colder, darker and emptier over time. Then again, our real Universe, with gravity, probably awaits a more or less similar fate. So in the very end, there may not be that much difference.

The funny thing is: a Universe without gravity is actually impossible. As a thought experiment, it's an interesting concept to consider, but according to Albert Einstein's general theory of relativity, gravity is an inevitable property of our world. That's because there is an intimate connection between space, time and gravity, the three of which are all intertwined through the constancy of the speed of light.

Just as well. Yes, it would be wonderful to be able to fly. And yes, a world in which no one ever breaks a leg by falling down the stairs sounds great. But if the feeblest of the forces of nature didn't exist, our Universe would be no fun at all, and we wouldn't be here to wonder about its absence.

That's the gravity of the matter, isn't it?

Govert Schilling's latest book *The Astronomy Handbook* is published by Black Dog & Leventhal

Gravitational lensing is a gift to astronomers studying the furthest-distant objects

Lensed by gravity

Another upside of gravity is it bends light, giving us a new way to look at the Universe

During a total solar eclipse in 1919, British physicist Arthur Eddington famously confirmed Einstein's prediction that light rays are bent ever so slightly in a gravitational field. This phenomenon, known as gravitational lensing due to its ability to focus or disperse light much like a lens, has since been observed many times, particularly in Hubble and James Webb Space Telescope images. In these, the light of remote galaxies can be strongly amplified and distorted into elongated arcs by the gravity of a foreground galaxy or cluster.

Gravitational lensing is the result of the warping of spacetime by massive objects. In the case of black holes, the effect can even be so strong as to cause light rays to orbit the black hole. In fact, a black hole itself is an extreme example of spacetime bending. But even weak gravitational fields cause an observable effect, known as weak lensing, where galaxy images are very slightly deformed and statistical studies are required to bring it to light.

Since all forms of gravitating matter produce these lensing effects, the study of strong and weak gravitational lensing is a neat way of mapping dark matter, the otherwise invisible stuff that accounts for some 85 per cent of all the gravity in the Universe.

Astronomy Photographer of the Year

NOW OPEN FOR ENTRIES!

The world-leading astrophotography competition is back! Could yours be this year's best astronomy image?

It's time to pick out your best astro images from the last 12 months to see if you can be named the 2025 Astronomy Photographer of the Year.

The Royal Observatory Greenwich is once again asking you to submit your best night-sky images to compete for the grand prize of £10,000. The best image in each of the eight main categories will also take home £1,500, with the Runner Up and Highly Commended winners receiving £500 and £250 respectively. If you're a newcomer or prefer to show off your astronomy photography in a more creative way, there are two special prizes, each offering £750. Meanwhile, astronomers under the age of 16 can enter the Young Astronomy Photographer of the Year competition for free, with the chance of claiming the main prize of £1,500.

Get your entries in now to be in with the chance of winning!

Dates for your diary

Competition opens: 6 January 2025
Entry closing date: 3 March 2025
Entrance fee: £10 for 10 entries

How to enter and rules: Find out more by visiting the Astronomy Photographer of the Year website at **apy.rmg.co.uk**

An exhibition of the winning images will be on show at the National Maritime Museum, London

CATEGORIES

Planets, Comets and Asteroids

The year has been a fantastic time for Solar System observers, with a parade of planets and comet A3 Tsuchinshan–ATLAS streaking across the sky. If you managed to catch a wonderful shot, make sure you enter it into this category.

Aurorae

Some truly spectacular aurora displays have danced across the sky this year, stretching from the poles to as far south as the Caribbean. Whether it's the aurora borealis or australis, if you've captured the lights, showcase them here.

People and Space

From the dawn of humanity, people have felt a connection with the night sky. The People and Space category celebrates that, asking for images that place our human experience in the greater context of the Universe around us.

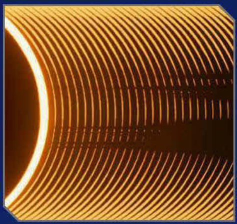
Skyscapes

The night sky can seem so distant at times, but a beautiful earthly foreground helps tether the two together. One of the competition's most contested categories, Skyscapes asks for any image also featuring a terrestrial landscape.

Our Moon

The Moon has been gaining increasing interest in recent years as humanity attempts to return to its surface. If you have a photo admiring our celestial neighbour from afar, be sure to enter it in the Our Moon category.

Our Sun



With the Sun due to hit the peak of its 11-year cycle of activity any day now, there's never been a better time to turn your camera on it (with the proper filters, of course). If you've imaged a fabulous flare or spectacular sunspot, enter it here.

BACKGROUND IMAGE: GETTY, EXHIBITION: NATIONAL MARITIME MUSEUM

OUR SOLAR SYSTEM

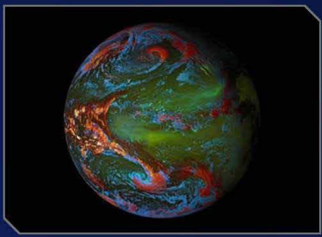
All the winning images will take pride of place at an exhibition in the National Maritime Museum

Stars and Nebulae

To the naked eye, stars and nebulae often appear as little more than shades of white and grey. But through astro photos, both can be transformed into explosions of colour and detail. This category aims to find the finest images of either.

Galaxies

The light from galaxies has been travelling for millions of years to reach us here on Earth. If you've captured that light from one of these distant star cities when it finally arrived, be sure to enter your photo in the Galaxies category.



Young Astronomy Photographer of the Year

Being young doesn't mean you can't take astounding astro images, and this special category aims to encourage the great photographers of tomorrow. If you are under the age of 16, you can enter the Young competition for free.

Special Prize: Patrick Moore Prize for Best Newcomer

Just because someone has just turned their camera on the night sky for the first time, doesn't mean they can't capture a truly astounding image. This special category is for images taken by those who just started astrophotography in the last year.

Special Prize: Annie Maunder Open Category

This prize celebrates using astronomical data in novel and creative ways. Use any data you have permission to use, whether you captured it yourself or it's from an open-source professional observatory. You can even take data from multiple sources.

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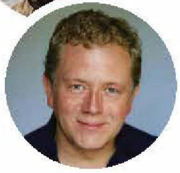

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BBC Sky at Night MAGAZINE

The Sky Guide

FEBRUARY 2025

PETE LAWRENCE

CATCH A CRESCENT VENUS

Don't miss the Evening Star looking elegant this month in its beautiful crescent phase

AN ASTEROID IN THE BEEHIVE

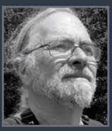
Can you get a photo of Bellona crossing M44?

WIDEFIELD WONDERS

Six binocular beauties around Canis Major

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four



Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- ✦ Titan and its shadow in transit
- ✦ Mars near the Moon's edge
- ✦ Crater Einstein
- ✦ Minor planet Amphitrite

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

FEBRUARY HIGHLIGHTS

Your guide to the night sky this month

Saturday

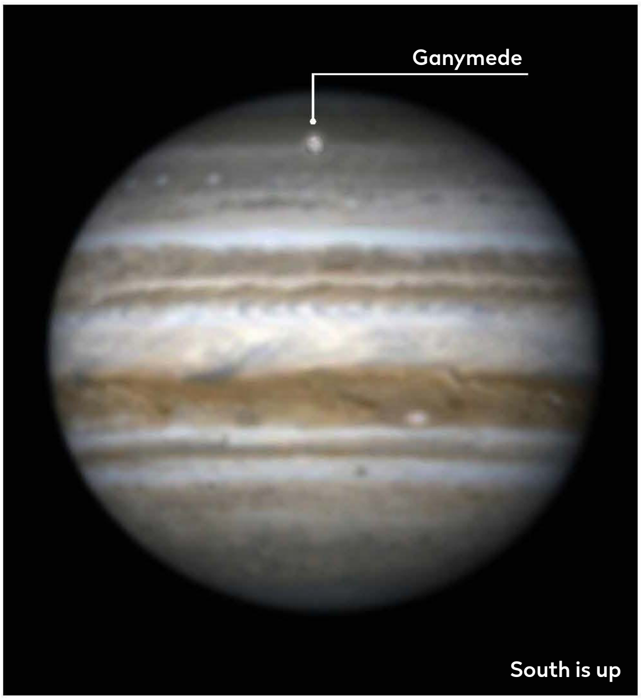
1

Venus, Saturn and Neptune are in the same evening twilight area of the sky, this evening joined by a 12%-lit waxing crescent Moon. You'll need binoculars to spot dim Neptune.

Tuesday ▶

4

Jupiter's largest moon, Ganymede, can be seen transiting the planet from 01:51 UT until Jupiter sets at 04:04 UT.



◀ Thursday

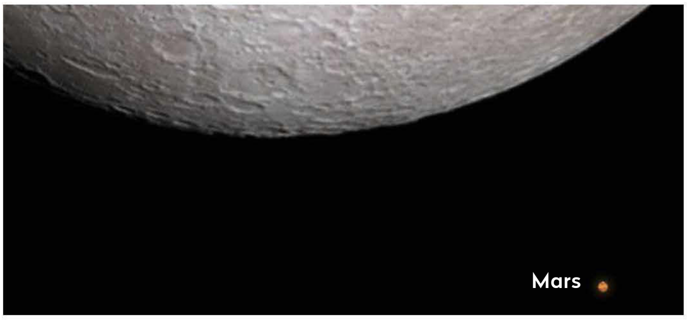
6

Libration currently favours the southeast region of the Moon, where you'll find a cluster of dark lava-filled craters, such as 141km Lyot, 73km Oken and 79km Jeans, right on the edge.

Sunday ▶

9

Viewed from the centre of the UK, mag. –0.8 Mars lies approximately 4.8 arcminutes south of the Moon's southern edge at 18:57 UT today. For those further north in the UK, the separation will be even smaller.



Monday

10

Today, evening planet Venus appears 30% illuminated through the eyepiece. The planet's apparent diameter is currently 36 arcseconds.

Friday

14

There's a chance to see the Zeno Steps around 04:00 UT today, a lunar clair-obscur effect that resembles a set of steps near the 65km crater Zeno.

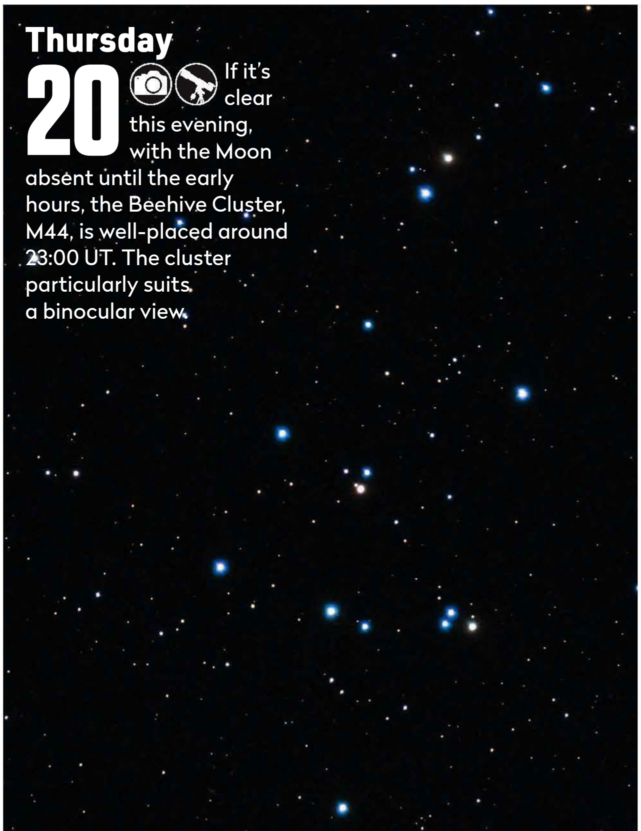
Monday

17

Today, evening planet Venus appears 25% illuminated through the eyepiece. The planet's apparent diameter is currently 40 arcseconds.

Family stargazing

Venus is a dramatic sight visible shortly after sunset. Point out the planet, describing how it's a similar size to Earth but is shrouded in thick clouds and very inhospitable to life. Venus is showing a crescent phase at the moment, which is easy to see. If you have binoculars or a telescope, without revealing what they are looking for, ask your young observer(s) whether they can see anything special about the planet. If you have a group, ask each one to make a sketch, then compare the results once everyone has completed the task. **www.bbc.co.uk/cbeebies/shows/stargazing**

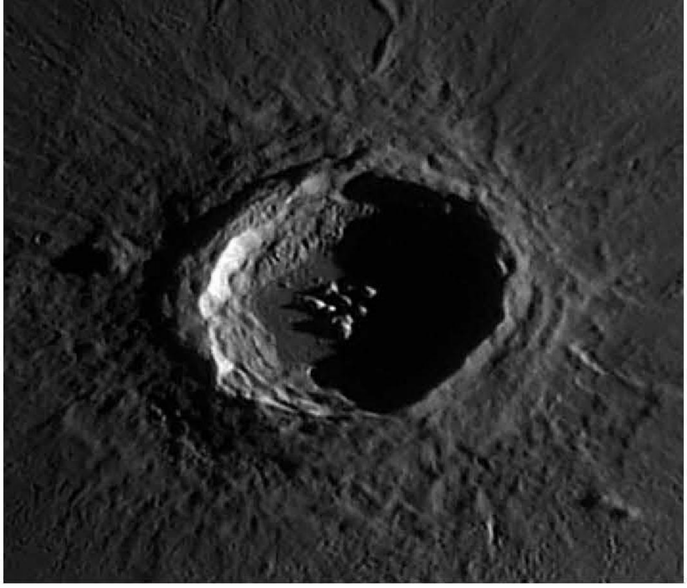


Thursday

20

If it's clear this evening, with the Moon absent until the early hours, the Beehive Cluster, M44, is well-placed around 23:00 UT. The cluster particularly suits a binocular view.

PETE LAWRENCE X 8



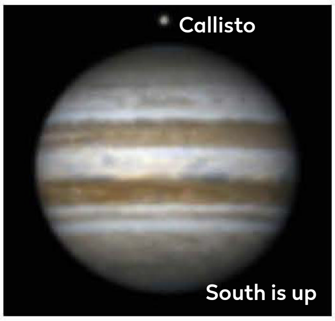
Wednesday ▶
5

This evening, the centre of the 55%-lit waxing gibbous Moon sits 4.1° north of mag. +5.7 Uranus.

The Stars of Aristillus lunar clair-obscur effect can be seen around 22:45 UT.

Friday
7

At around 02:45 UT today, the centre of the 69%-lit waxing gibbous Moon sits 4.8° north of mag. –2.3 Jupiter as both objects approach the northwest horizon.



◀ Saturday
8

Callisto sits 3 arcseconds south of Jupiter's southern pole at 19:08 UT.

Although hard to observe in daylight, Titan transits Saturn from 12:48 until 16:28 UT, its shadow following at 14:38–20:20 UT.

Wednesday
12

Minor planet 29 Amphitrite reaches opposition today. Turn to page 53 for more information.

Thursday ▶
13

Magnitude +1.3 Regulus (Alpha (α) Leonis) sits 1.2° south of the Moon's southern edge at 01:00 UT this morning.

Saturday
22

Evening planet Venus now appears 20% illuminated through the eyepiece, a beautiful and stunning crescent. The planet's apparent diameter is currently 44 arcseconds.

Monday
24

Another tricky Titan-and-shadow transit that starts in daylight, Titan crossing at 12:28–17:55 UT and its shadow following at 13:45–19:45 UT. Saturn sets at around 18:50 UT.

Tuesday
25

The shadow of Ganymede transits Jupiter's disc at 18:35–21:12 UT and the moon Europa keeps pace at the same time. Europa's shadow transits at 21:00–23:36 UT, while Io undergoes an occultation disappearance at 21:05 UT.

Thursday ▶
27

This evening, Venus appears 15% illuminated through the eyepiece with an apparent diameter of 47 arcseconds.

Friday
28

There's a chance to spot a thin Moon this evening as a less than 1%-lit waxing crescent sets 50 minutes after the Sun.

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal Time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **bit.ly/stargazing-top-tips** to learn how to stargaze in 12 easy steps and **bit.ly/choose-first-telescope** for advice on choosing your first scope

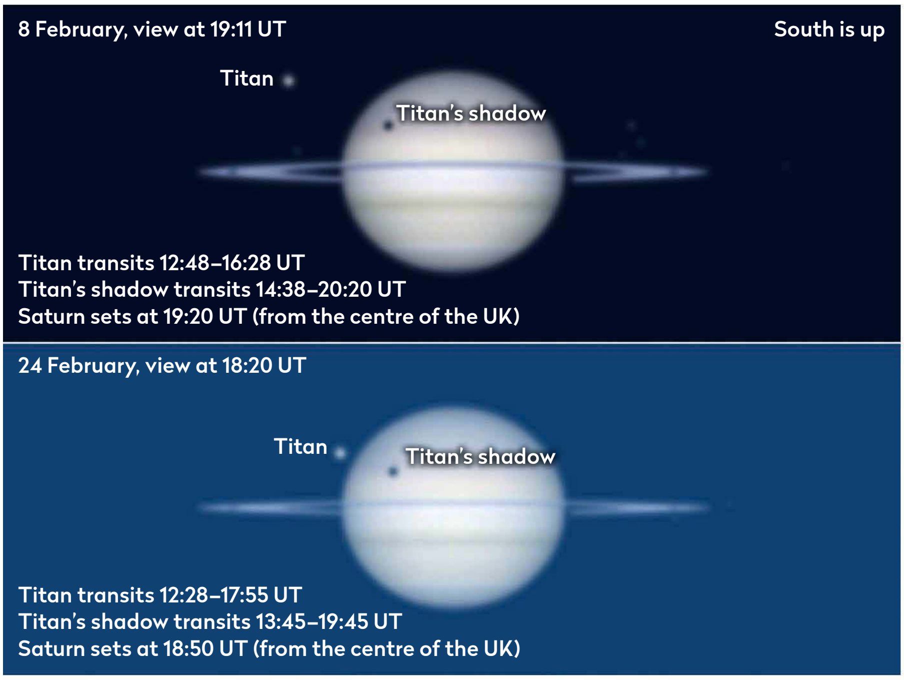
THE BIG THREE

The top sights to observe or image this month

DON'T MISS

Titan and its shadow

BEST TIME TO SEE: 8 February 12:48–19:20 UT, 24 February 12:28–18:50 UT


8 February, view at 19:11 UT

Titan transits 12:48–16:28 UT
Titan's shadow transits 14:38–20:20 UT
Saturn sets at 19:20 UT (from the centre of the UK)

24 February, view at 18:20 UT

Titan transits 12:28–17:55 UT
Titan's shadow transits 13:45–19:45 UT
Saturn sets at 18:50 UT (from the centre of the UK)

▲ **Saturn has two transits of moon Titan and its shadow this month**

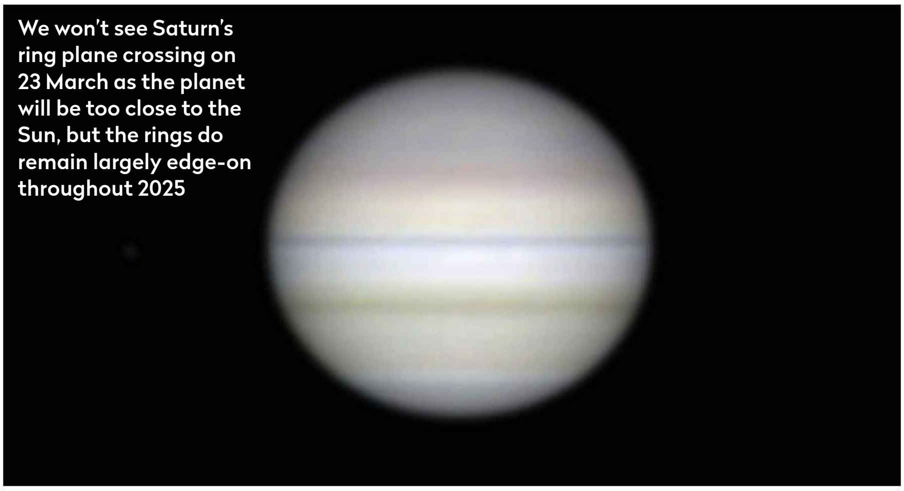
Titan is Saturn's largest moon. Its large orbit, combined with Saturn's axial tilt of 26.73°, means that from Earth its orbit typically traces out a tangible ellipse. As a result, when Titan passes Saturn it either appears to move north or south of the planet's globe. However, things are unusual at the moment and from the perspective of Earth and the Sun, Saturn appears almost sideways-on.

From the Sun's perspective, Saturn will appear edge-on on 6 May of this year, the planet then being at an equinox. From Earth, Saturn appears sideways-on a little earlier, on 23 March, the date when we experience what's known as a ring plane crossing. The bad news for us is that the ring plane crossing occurs when Saturn is too close to the Sun to be seen properly. The good news is that from Earth, Saturn's virtually edge-on appearance persists throughout 2025, and actually becomes quite shallow again towards the end of the year.

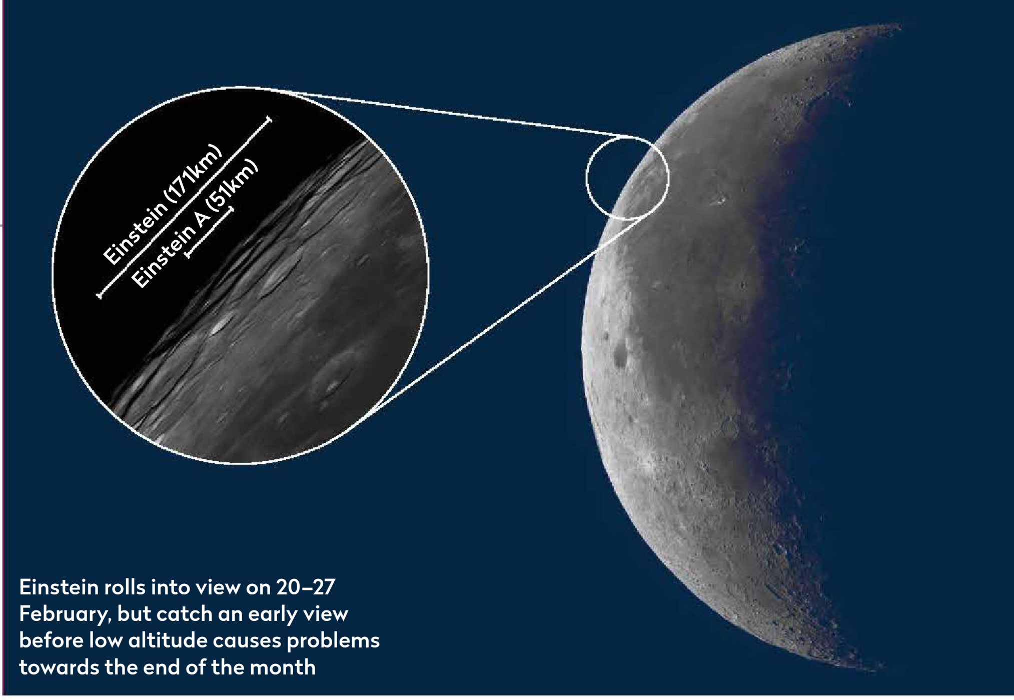
When Saturn appears nearly sideways-on, Titan's orbit reduces to the thinnest of ellipses. The moon and its shadow are then able to pass across Saturn's globe. Such transit events occur at 16-day intervals (actually 15 days, 22 hours and 40 minutes), which means the events occur approximately 80 minutes earlier roughly every 16 days. This is important, because if the events are badly timed – occurring during the day, for example – they'll take a while to slowly move into the night period. As a consequence, these rare events may need a bit of work to see.

Before the March ring plane crossing, there are a couple of transits in February. On 8 February, Titan transits Saturn between 12:48 and 16:28 UT, a daylight event. Although Saturn can be seen by day through a telescope, the relative dimness of the planet leaves it as a very low-contrast object in a blue sky. More encouraging is the shadow transit that follows, occurring between 14:38 and 20:20 UT, with Saturn setting at 19:20 UT, one hour before the shadow transit concludes. The latter stages of this event are visible under deep twilight conditions.

Then 16 days later, on 24 February, Titan is at it once again, transiting the planet between 12:28 and 17:55 UT, its shadow following between 13:45 and 19:45 UT. Saturn once again sets an hour before the event's conclusion, at 18:50 UT. Your best chance of grabbing a view of these events will be in the latter stages of the shadow transits, which can be seen under deep twilight. Don't worry if you miss them, though – there are further, better-timed events scheduled for later in 2025.


We won't see Saturn's ring plane crossing on 23 March as the planet will be too close to the Sun, but the rings do remain largely edge-on throughout 2025

ALL PICTURES: PETE LAWRENCE



Einstein rolls into view on 20–27 February, but catch an early view before low altitude causes problems towards the end of the month

Einstein on view

BEST TIME TO SEE: 20–27 February

The Moon's familiar face varies by a small amount over time, due to an effect known as libration. Libration occurs as a result of the Moon's elliptical orbit being tilted to our own orbital plane by around 5°, making our natural satellite rock and roll slightly on its axis. As you might expect, this results in some features becoming better placed for viewing or even appearing when they are normally hidden, and vice versa. Such features are described as being located in the Moon's libration zone.

One such feature is the 171km crater Einstein. It's perfectly placed for the game of libration hide-and-seek, often hiding around the Moon's western limb and only rolling into view from time to time.

In order to see it, libration has to be favourable, the Moon has to be above the horizon and the weather needs to be clear. The Moon's phase also has to be such that Einstein is illuminated by the Sun, preferably with the Sun low in Einstein's sky to create relief shadows.

Such a list of demands for the perfect view means that opportunities to see Einstein at its best are fairly infrequent and should be grabbed when they happen, weather permitting of course. Visible through a small telescope, Einstein will appear as a narrow ellipse near to the western limb on the morning of 23 February, the Moon's phase being reasonable but not perfect, with limited shadow relief. The phase improves over the following mornings but the Moon becomes very low at sunrise.

Einstein has a large concentric inner crater, Einstein A, which is 50km across. Together with its primary, they form a striking pair if you are lucky enough to have all of those tricky and demanding view requirements just right.

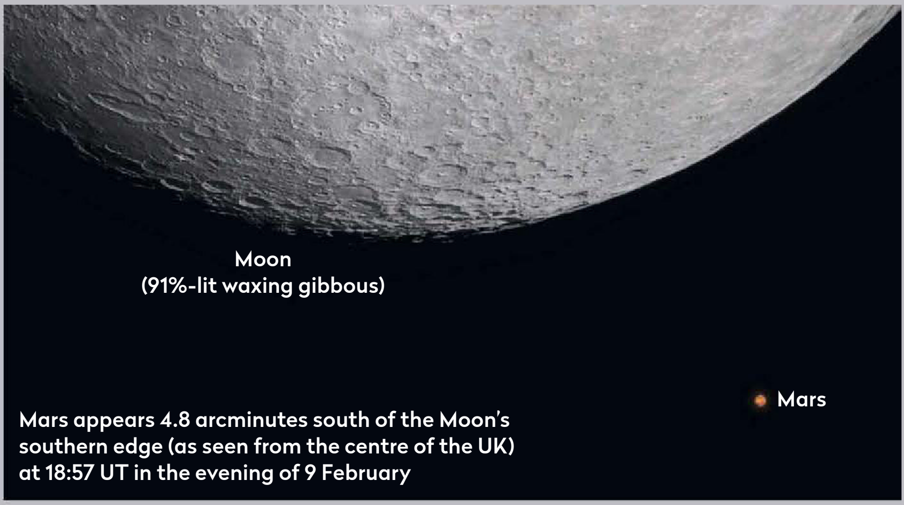
Mars and the Moon

BEST TIME TO SEE: 9 February, closest at 18:57 UT

Mars and the Moon will appear close to one another on 9 February. Actually, the Moon's monthly movement around the sky often takes it close to each planet, but in this case the proximity will be very close, Mars sitting just 20 arcminutes south of the Moon's centre at 18:57 UT, which places it 4.8 arcminutes from the Moon's southern limb at this time. This is close enough for images taken of the planet to show good lunar detail and Mars's disc in the same frame.

Although not as dramatic as a lunar occultation of Mars, the alignment offers an exciting opportunity to get some great shots of the Moon's edge and the planet's disc. Mars is still fairly large, thanks to having been at opposition last month. As a consequence, Mars will appear around 12 arcseconds across. Of course, imaging is not the only method of enjoying such a view, and a telescope with a low- to mid-power eyepiece should give you a stunning visual of the encounter.

Lunar parallax – the apparent shift of the Moon's position depending on the location from which you're viewing it – will have an effect too. Those further to the north of the UK will see the separation reduce, while those living in southern parts of the country will see slightly greater separation.



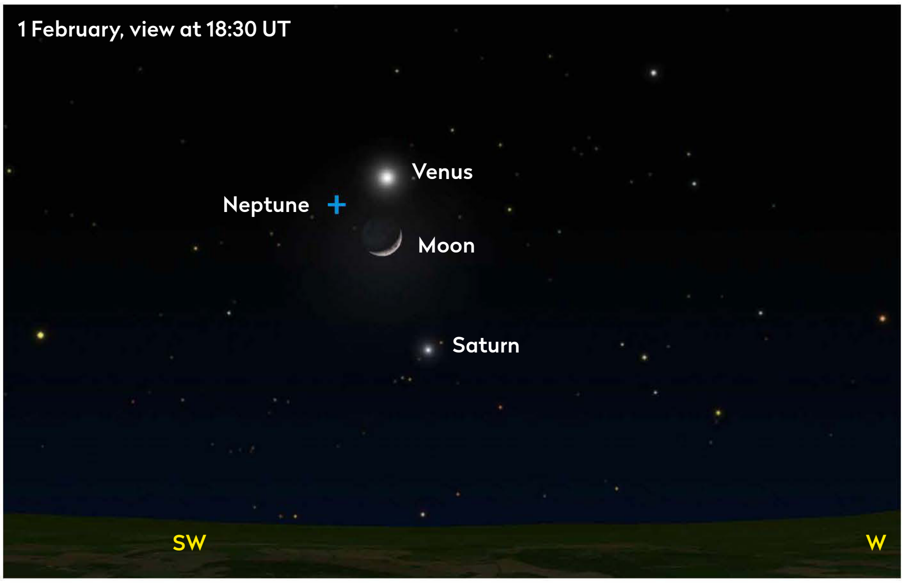
Mars appears 4.8 arcminutes south of the Moon's southern edge (as seen from the centre of the UK) at 18:57 UT in the evening of 9 February

THE PLANETS Our celestial neighbourhood in February

PICK OF THE MONTH

Venus

Best time to see: 1 February, 1 hour after sunset
Altitude: 28°
Location: Pisces
Direction: Southwest
Features: Phase, subtle atmospheric markings
Recommended equipment: 75mm scope or larger


1 February, view at 18:30 UT
Venus
Neptune
Moon
Saturn
SW
W

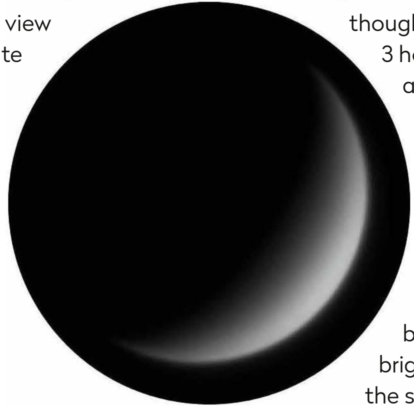
▲ A crescent Moon near Venus, Saturn and Neptune. You can see a similar scene on 1 March

Beautiful Venus grabs the early-evening attention during February, a sparkling jewel visible soon after the Sun has set, or indeed before, if you know where to look. Once the Sun sets and twilight begins to darken, under clear skies Venus really pops into view. At the start of February, it's possible to see it shining at mag. –4.5 against a totally dark sky.

On 1 February, Venus sets 4 hours and 24 minutes after the Sun. A 13%-lit waxing crescent Moon sits 3.3° to the south of Venus at 20:00 UT. Through the eyepiece, Venus appears 32 arcseconds across as a beautiful 37%-lit crescent.

As February progresses, Venus remains well placed, only slowly degrading as it moves back towards the Sun at the end of the month. On 15 February, for example, Venus sets 4 hours after sunset and retains its intense brightness at mag. –4.5. An eyepiece view of the planet on this date will show it larger at 39 arcseconds across. Its phase will have decreased to 26%.

By 28 February, things will have started to change thanks to Venus moving slowly back towards the Sun. An eyepiece view shows it now appears 48 arcseconds across as a slender crescent just 14% lit. The expanding pre-spring twilight makes its presence known at the end of the month though, the planet setting 3 hours and 15 minutes after sunset but now getting low as true darkness falls.



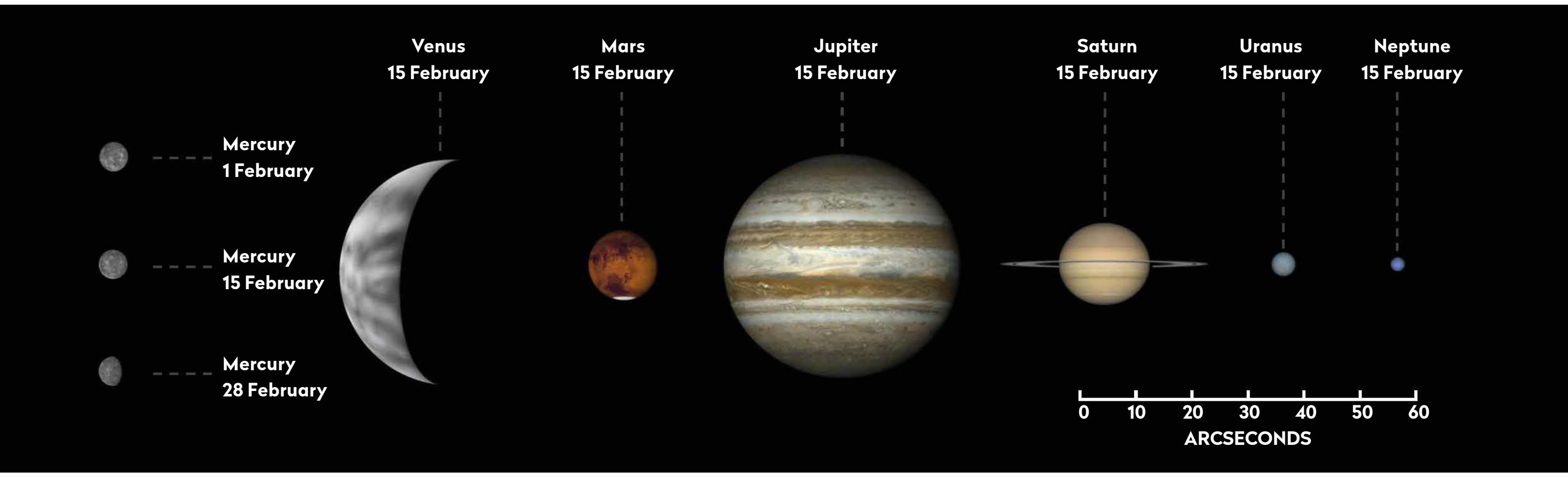
▲ Always a joy to behold, Venus will be in its crescent phase throughout February

Tempting though it is to get a telescopic view of Venus when it's in a dark sky, the best views are likely to be when the sky is still bright, when it's higher in the sky, in a more stable atmosphere. The brighter sky will also help reduce the planet's intense glare.

PETE LAWRENCE X 2

The planets in February

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope


Venus
15 February
Mars
15 February
Jupiter
15 February
Saturn
15 February
Uranus
15 February
Neptune
15 February
Mercury
1 February
Mercury
15 February
Mercury
28 February
0
10
20
30
40
50
60
ARCSECONDS

Mercury

Best time to see: 28 February, from 30 minutes before sunrise
Altitude: 8° (low)
Location: Pisces
Direction: West

Mercury is too close to the Sun in the morning sky to be seen properly at the start of February, reaching superior conjunction on 9 February. After this date it emerges slowly into the evening sky. On 24 February, Mercury sets 1 hour and 10 minutes after the Sun, shines at mag. –1.1 and appears 5 arcseconds across through the eyepiece, with a phase of 87%. Best seen from 30 minutes after sunset at the end of the month, it is quite low. Mercury and Saturn are 1.5° apart on 25 February.

Mars

Best time to see: 1 February, 22:50 UT
Altitude: 63°
Location: Gemini
Direction: South

Mars was at opposition last month and remains well presented, managing a peak altitude of 63° when due south. On 1 February, shining at mag. –1.1, Mars appears 13 arcseconds across through the eyepiece. On 9 February, it sits 20 arcminutes south of the centre of the 91%-lit waxing Moon at 18:57 UT. On 24 February, Mars appears to reverse direction, reverting from westward to eastward movement. By 28 February, Mars dims to mag. –0.3 and appears 10 arcseconds across.

Jupiter

Best time to see: 1 February, 20:00 UT
Altitude: 59°
Location: Taurus
Direction: South

Jupiter is a magnificent planet throughout February, bright and able to reach an altitude of nearly 60°. Currently located in Taurus, it shines at mag. –2.4 on 1 February, reaching peak altitude around 20:00 UT. A 69%-lit waxing gibbous Moon sits 4.8° north of Jupiter on the morning of 7 February, closest just before both objects set.

By the end of the month, Jupiter's observing window begins to falter, the planet now appearing just west of south as true darkness falls. Don't let this put you off though, as it's still really well presented.

Saturn

Best time to see: 1 February, 18:00 UT
Altitude: 17°
Location: Aquarius
Direction: Southwest

Saturn's observing window closes this month, the evening planet becoming too low to be viable. Still visible at the start of February, a mag. +0.8 object shining in the deep twilight.

Uranus

Best time to see: 1 February, 18:50 UT
Altitude: 55°
Location: Aries
Direction: South

Well-placed mag. +5.7 evening planet in Aries at the start of February, but losing altitude as true darkness falls at the end of the month.

Neptune

Best time to see: 1 February, 19:00 UT
Altitude: 17°
Location: Pisces
Direction: Southwest

Mag. +7.9 Neptune is 3.3° southwest of Venus on 1 February, but rapidly becomes unviable from there on.

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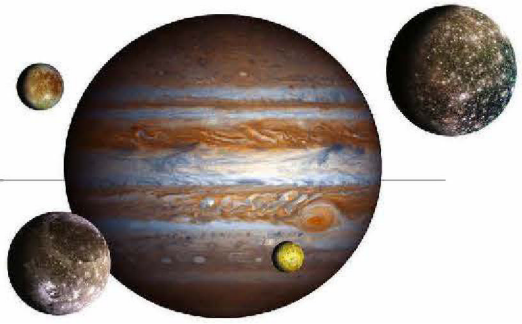
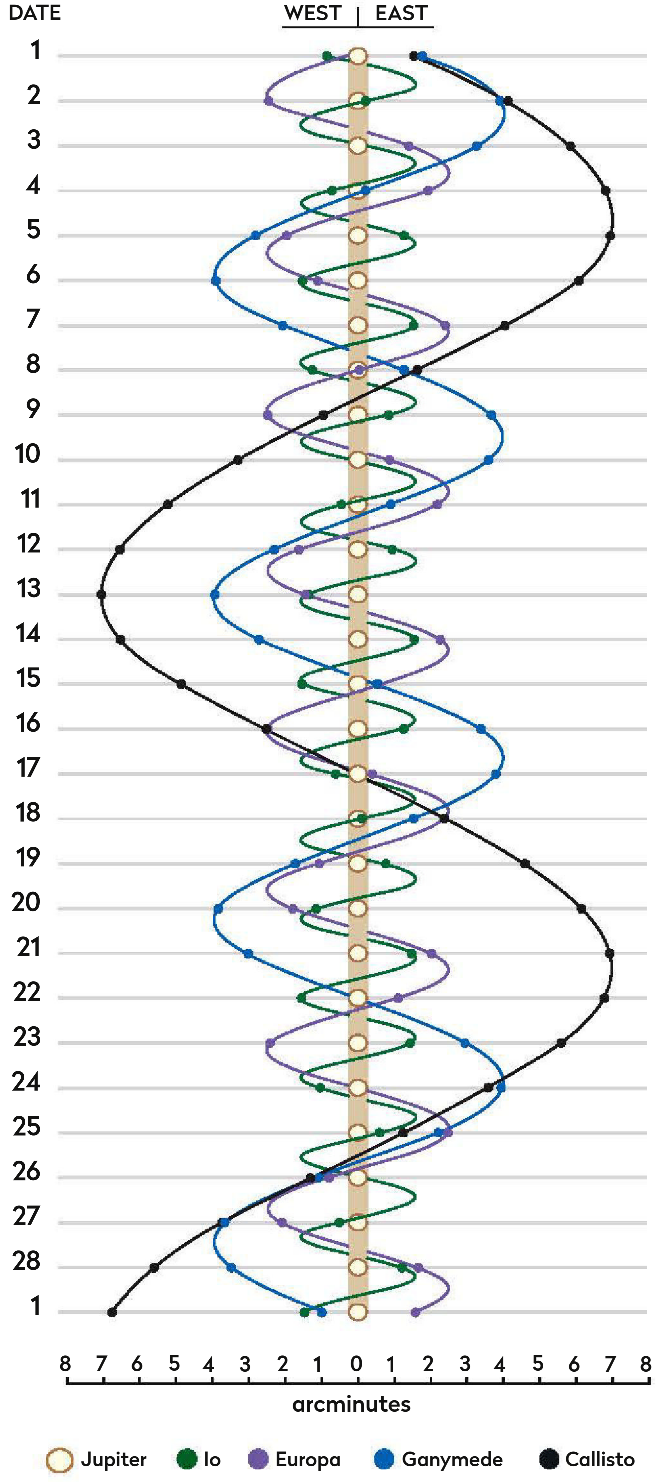


JUPITER'S MOONS: FEBRUARY

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically over the month, as shown on the diagram. The line by each date represents 00:00 UT.



THE NIGHT SKY – FEBRUARY

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

Arcturus	STAR NAME
PERSEUS	CONSTELLATION NAME
⬭	GALAXY
◌ ⁘	OPEN CLUSTER
⊕	GLOBULAR CLUSTER
☼	PLANETARY NEBULA
☐	DIFFUSE NEBULOSITY
●	DOUBLE STAR
○	VARIABLE STAR
◐	THE MOON, SHOWING PHASE
	COMET TRACK
	ASTEROID TRACK
	STAR-HOPPING PATH
△	METEOR RADIANT
Circlet	ASTERISM
	PLANET
	QUASAR

STAR BRIGHTNESS:

●	MAG. 0 & BRIGHTER
●	MAG. +1
•	MAG. +2
·	MAG. +3
·	MAG. +4 & FAINTER

5° N E W S	COMPASS AND FIELD OF VIEW
	MILKY WAY

CHART: PETE LAWRENCE

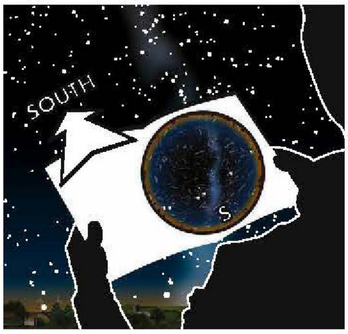
When to use this chart

1 February at 00:00 UT
15 February at 23:00 UT
28 February at 22:00 UT

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.



Sunrise/sunset in February*

Date	Sunrise	Sunset
1 Feb 2025	07:54 UT	16:53 UT
11 Feb 2025	07:36 UT	17:13 UT
21 Feb 2025	07:15 UT	17:32 UT
3 Mar 2025	06:52 UT	17:52 UT

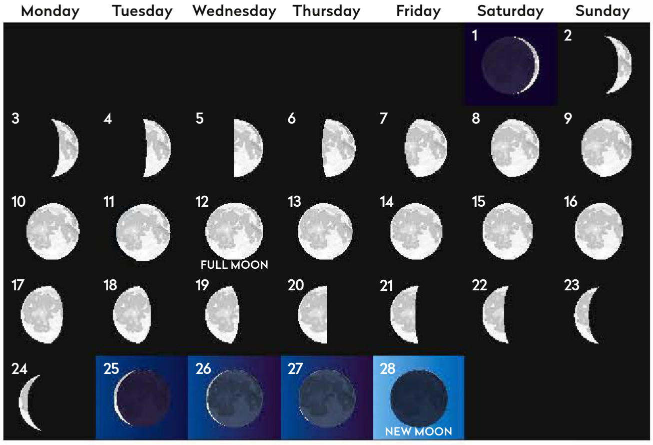
Moonrise in February*

Moonrise times

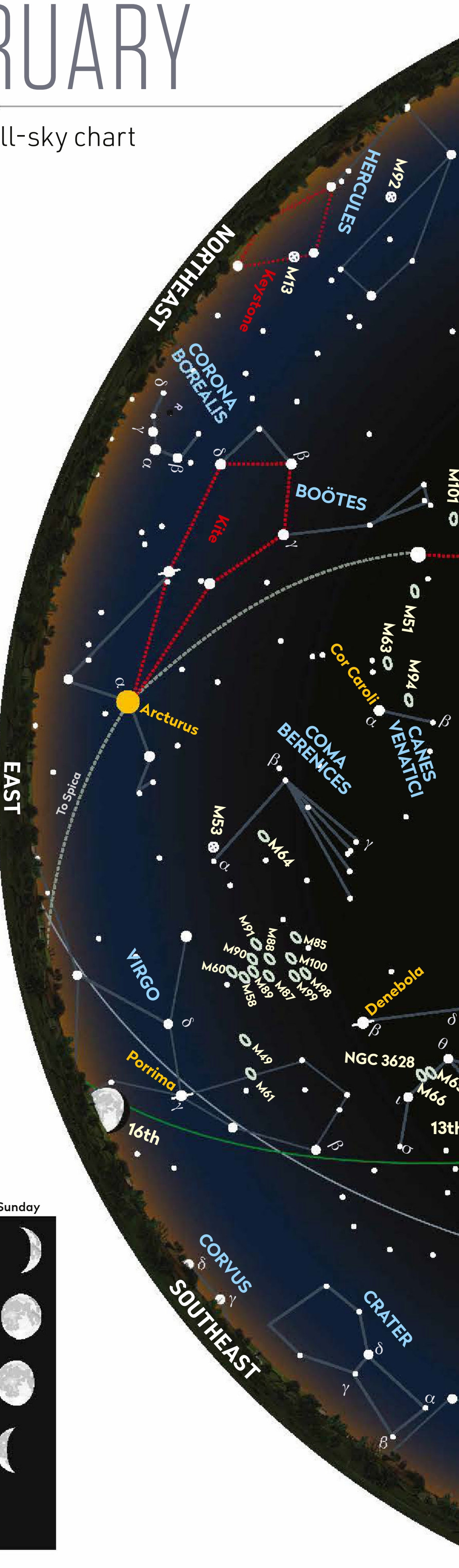
1 Feb 2025, 09:13 UT
5 Feb 2025, 10:00 UT
9 Feb 2025, 12:58 UT
13 Feb 2025, 18:26 UT
17 Feb 2025, 23:21 UT
21 Feb 2025, 03:11 UT
25 Feb 2025, 06:35 UT
1 Mar 2025, 07:31 UT

*Times correct for the centre of the UK

Lunar phases in February



Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
					1	2
3	4	5	6	7	8	9
10	11	12 FULL MOON	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28 NEW MOON		


M92
HERCULES
M13
Keystone
NORTHEAST
CORONA BOREALIS
δ
γ
α
β
δ
β
BOÖTES
M101
Kite
γ
M51
M63
M94
Cor Caroli
α
β
CANES VENATICI
COMA BERENICES
β
α
Arcturus
EAST
To Spica
M53
α
M64
γ
M91
M88
M85
M90
M100
M60
M58
M89
M87
M99
M98
VIRGO
δ
Denebola
β
δ
θ
NGC 3628
M65
M66
ι
13th
Porrima
γ
M49
M61
16th
β
CORVUS
δ
γ
SOUTHEAST
CRATER
δ
γ
α
β

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Paul and Pete's
night-sky highlights

Southern Hemisphere guide

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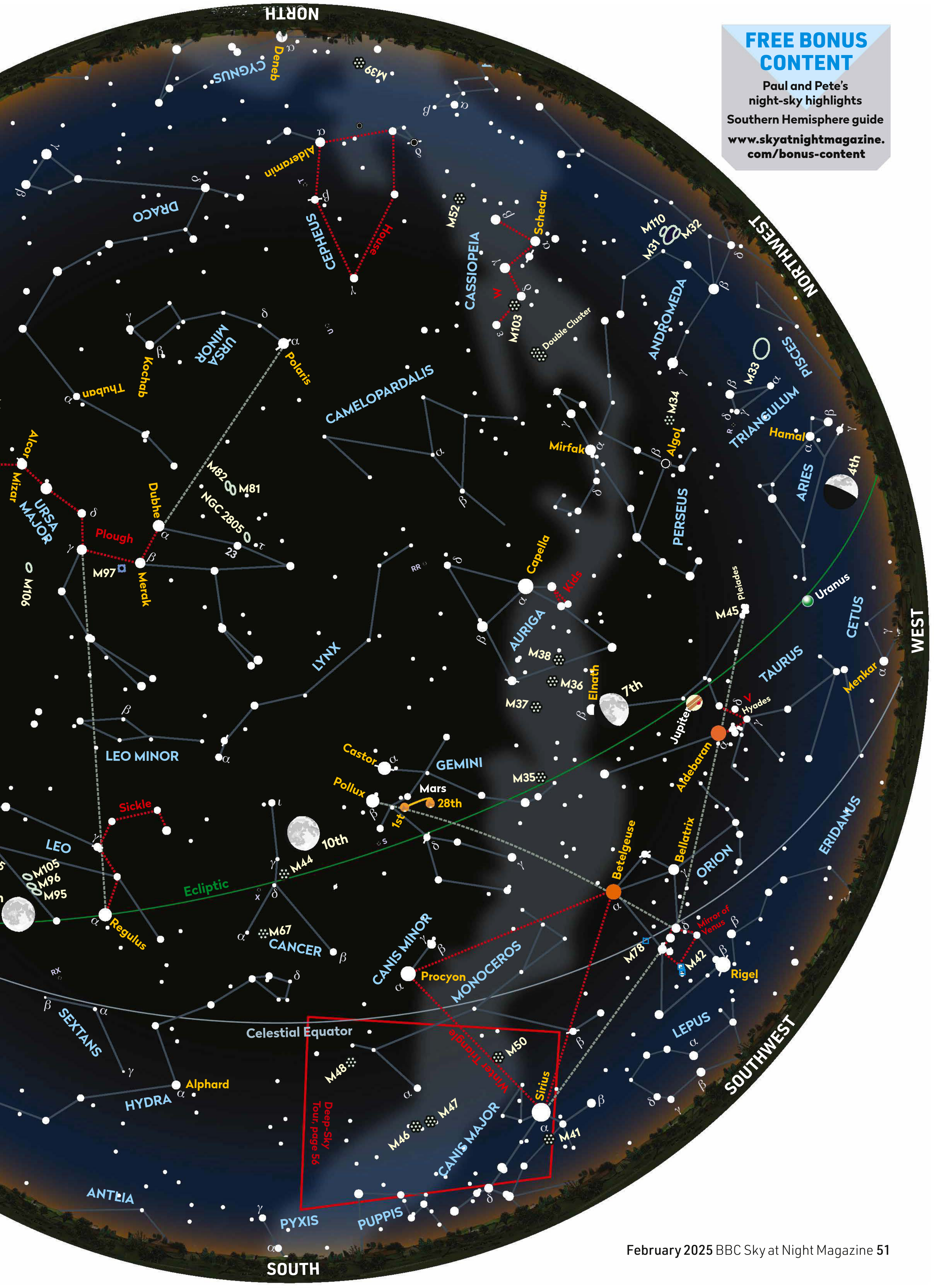
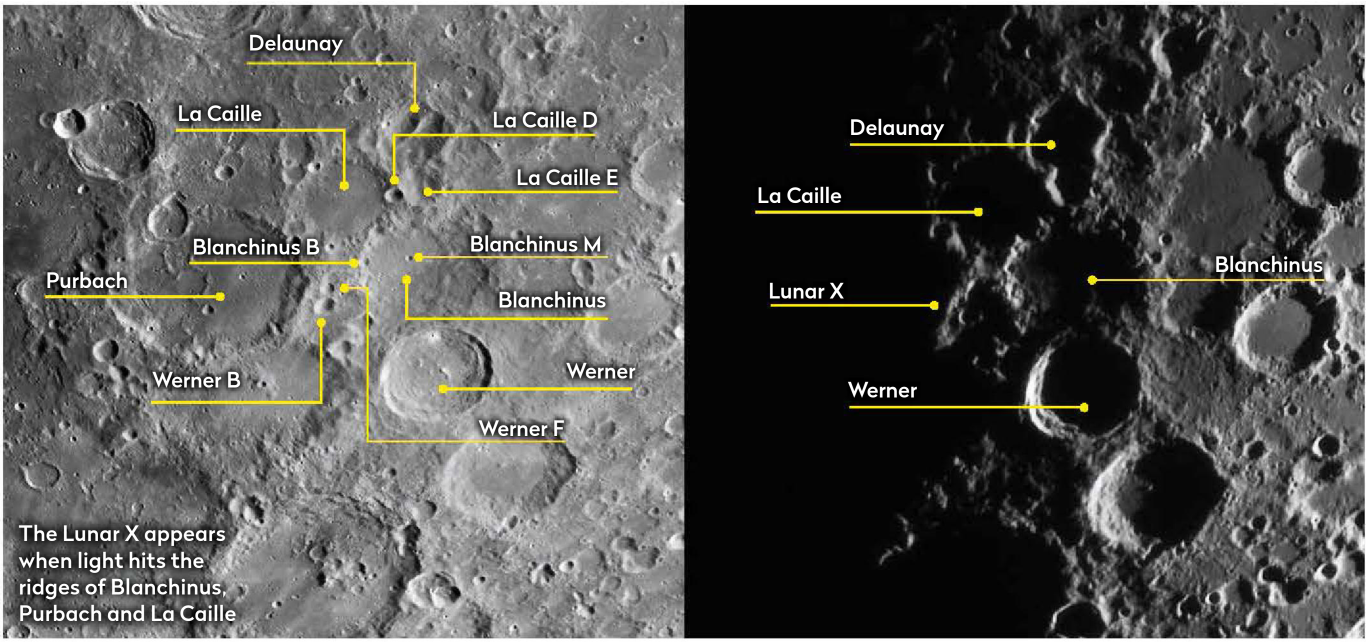

NORTH
CYGNUS
Deneb
M39
Alderamin
CEPHEUS
House
DRACO
M52
CASSIOPEIA
Schedar
W
M103
Double Cluster
M110
M31
M32
ANDROMEDA
NORTHWEST
M33
PISCES
TRIANGULUM
Hamal
ARIES
4th
URSA MINOR
Kochab
Thuban
Polaris
CAMELOPARDALIS
M34
Algol
Mirfak
PERSEUS
Alcor
Mizar
URSA MAJOR
Dubhe
M82
M81
NGC 2805
23
Plough
M97
Merak
M106
Capella
Kids
AURIGA
RR
Uranus
CETUS
M45
Pleiades
WEST
LYNX
M38
M36
M37
Elnath
7th
TAURUS
Menkar
Jupiter
Hyades
Aldebaran
LEO MINOR
Castor
GEMINI
M35
Pollux
Mars
28th
1st
Sickle
10th
LEO
M105
M96
M95
M44
Ecliptic
Betelgeuse
Bellatrix
ORION
ERIDANUS
Regulus
M67
CANCER
CANIS MINOR
Mirror of Venus
M78
M42
Rigel
Procyon
MONOCEROS
RX
SEXTANS
Celestial Equator
Winter Triangle
M50
LEPUS
SOUTHWEST
M48
Deep-Sky Tour, page 56
Sirius
Alphard
HYDRA
M46
M47
CANIS MAJOR
M41
ANTLIA
PYXIS
PUPPIS
SOUTH

MOONWATCH

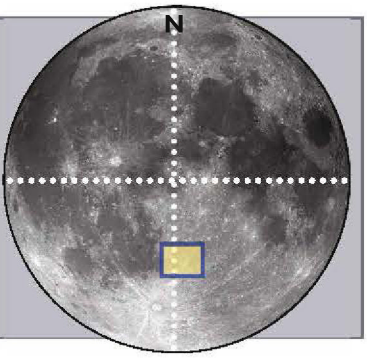
February's top lunar feature to observe



The Lunar X appears when light hits the ridges of Blanchinus, Purbach and La Caille

Blanchinus

Type: Crater
Size: 68km
Longitude/latitude: 2.5° E, 25.3° S
Age: Older than 3.9 billion years
Best time to see: First quarter (5–6 February) or six days after full Moon (19–20 February)
Minimum equipment: 50mm telescope



If you're a fan of observing the Moon, you might have seen crater **Blanchinus** without even realising it. That's because it's one of the craters that contributes to forming the famous clair-obscur effect known as the Lunar X. The partially illuminated rims of Blanchinus, 68km **La Caille** and 118km **Purbach** together form the 'X' near to the first quarter phase.

As a stand-alone crater, Blanchinus is less impressive as its ancient form has been heavily eroded. La Caille to the northwest is a good comparison, because despite having a similar age, it appears much cleaner-cut, with a well-defined rim and flat pock-marked floor. Blanchinus's rim is extremely worn and appears to merge with the surrounding highland areas at certain positions. Like La Caille, Blanchinus's floor is flat with no hint of a central mountain complex. It's also covered by a smattering of smaller craterlets, the largest of which is 4.1km **Blanchinus M**, just north of Blanchinus's centre. A curious triplet of craterlets can be seen on Blanchinus's floor near the western rim. Each of these is around 2.1km across and individually will need a 300mm telescope and good seeing to see properly.

> ***Blanchinus is one of the craters that forms the famous Lunar X***

The main floor area is uneven and a continuous roughness appears to flow across it. Again, compare Blanchinus's floor with that of La Caille, the latter having a more classical flat lava appearance. Under oblique lighting when the terminator is nearby, the roughness of Blanchinus's floor appears to be more organised, like parallel ridges or furrows running north-northwest to south-southeast.

It's the northwest section of Blanchinus's rim that is visible as part of the Lunar X, a section that appears to be moulded by craterlets, the largest of which is 7.2km **Blanchinus B**. The main body of the X is formed by the elevated highland region between Blanchinus and Purbach to the west, the curved rim of La Caille forming the northern part of the letter. The southern portion is formed by a fortuitously lower section of highland interrupted by two craters: 9.5km **Werner F** and 13.3km **Werner B**. Werner is the beautifully preserved 70km crater immediately south of Blanchinus. With a sharp rim and terraced interior rim walls leading down to a bumpy but level floor with a small central mountain, Werner's a classic crater. Its distinctive appearance comes from the fact that it's younger than Blanchinus and La Caille, at somewhere between 1.1 and 3.2 billion years old. An alternative name for the Lunar X is the Werner X, despite the fact that Werner doesn't really contribute to the X's shape.

Heading north from Blanchinus first brings you to 11.1km **La Caille D** and the less defined 27.7km **La Caille E**. Further north still is the oddly shaped 46km **Delaunay**, a fascinating feature to observe when the terminator is nearby, its irregular shape divided in half by a ridge running northeast to southwest across its full diameter.

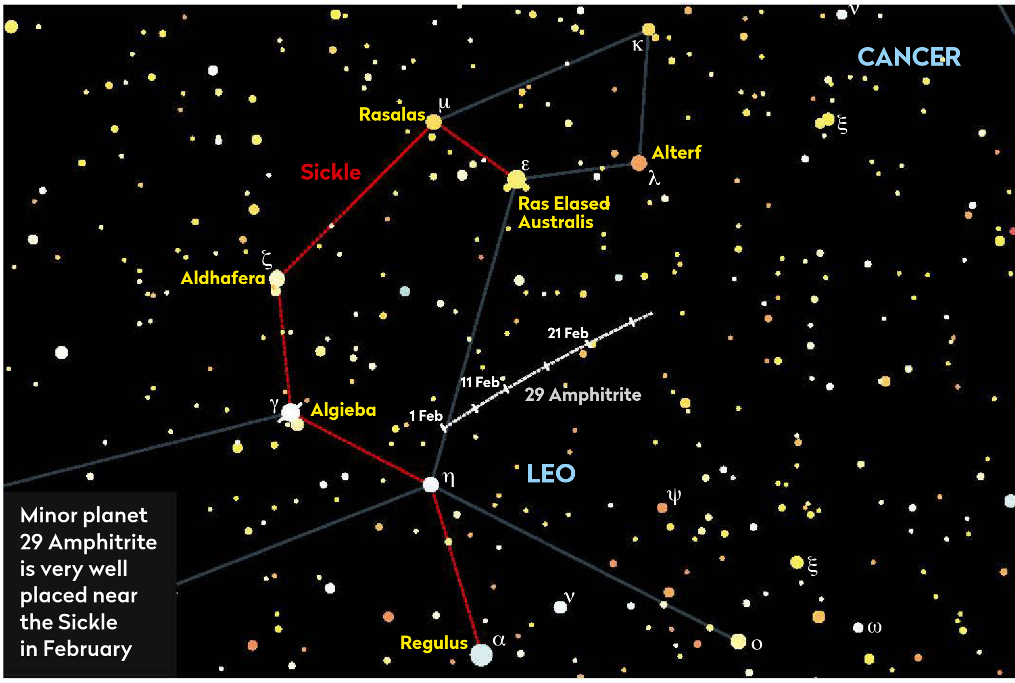
COMETS AND ASTEROIDS

Watch 29 Amphitrite brighten in Leo this month

Minor planet 29 Amphitrite reaches opposition on 12 February, when it can be found very close to the very recognisable Sickle asterism in Leo.

It starts the month 1.5° northwest of mag. +3.5 Eta (η) Leonis, the star immediately north of Regulus (Alpha (α) Leonis). From here it tracks west and slightly north to end the month 4° south of mag. +4.3 Alterf, Lambda (λ) Leonis. On 1 February, 29 Amphitrite shines at mag. +9.5, placing it easily within small-scope territory. Its brightness increases slightly to +9.2 at opposition, then falls back to mag. +9.5 by the end of the month. Its total path length throughout February is just 6.5°.

As ever, the best way to identify a minor planet is to photograph or sketch the area it's supposed to be in over several nights and compare the results. If you spot something moving which is in the correct magnitude range, it's probably your target.



Minor planet 29 Amphitrite is very well placed near the Sickle in February

Amphitrite is one of the largest S-type asteroids known, having a mean diameter around 204km. Its solar distance varies from 2.74 AU (410 million km) at aphelion to 2.37 AU (355 million km) at perihelion. Amphitrite takes 4.09 years to complete each orbit and rotates on its axis once every 5.4 hours.

STAR OF THE MONTH

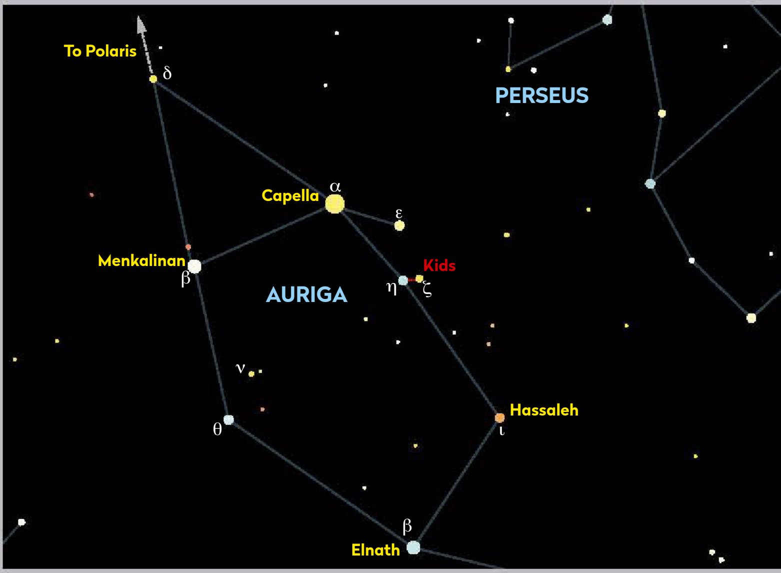
Delta Aurigae, an alternative pointer star

Delta (δ) Aurigae is the main star at the top of Auriga, the constellation that looks like a misshapen pentagon. Delta on top of the pentagon forms a triangle along with Capella (Alpha (α) Aurigae) and Menkalinan (Beta (β) Aurigae) as the triangle's base. It shines at mag. +3.7 and so is an easy naked-eye star, but despite its labelled position as Delta, it's outshone by Epsilon (ε), Eta (η), Theta (θ) and Iota (ι) Aurigae.

Delta's spectral class is K0 IIIb, K0 indicating an orange star and the IIIb indicating that it's a less luminous evolved giant star. It's slightly younger than our Sun at 3.26 billion years and is believed to be a red clump star, one that fuses helium in its core. It's also known to be a spectroscopic binary with an orbital period of 3.52 years. The main star is 1.63 times more massive than our Sun and approximately 11 times larger. It spins on its axis at the leisurely rate of 4km/s, twice the rotation speed of the Sun. The system is 141 lightyears distant.

Delta has a special place in the sky, forming an asterism with Menkalinan and Theta Aurigae that on a map appears like a perfectly straight line. Nothing special here you might think, until you realise that extending this line northwards points with an impressive degree of precision directly at Polaris, the North Star. Even the traditional 'pointer' stars, Dubhe (Alpha (α) Ursae Majoris) and Merak (Beta (β) Ursae Majoris), don't point as precisely as the Theta–Beta–Delta Aurigae line!

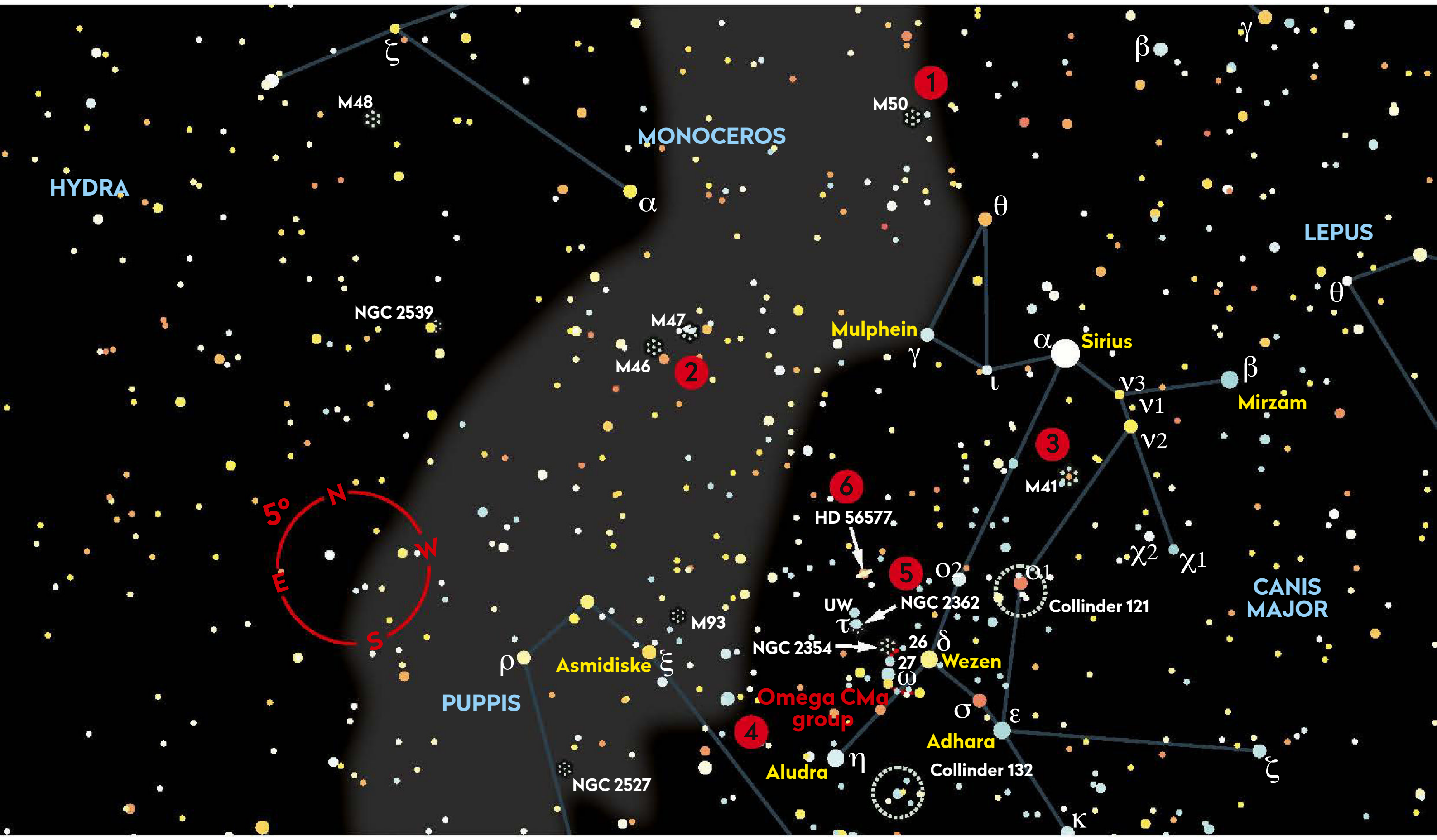
▼ Along with Theta and Beta, Delta Auriga points the way to the North Star



BINOCULAR TOUR

With Steve Tonkin

Enjoy a winter wander among some exquisite star clusters in and around Canis Major



PETE LAWRENCE X 3

1. M50

10x50 We start this month's tour with M50, one of several open clusters we'll visit this month. An easy way to find this lovely cluster is to navigate just over 5° north-northeast from mag. –1.1 Sirius (Alpha (α) Canis Majoris) to the mag. +4.0 star Theta (θ) Canis Majoris, then continue another 4° in the same direction. You'll see M50 as a circular glow about half the apparent diameter of the Moon. M50 lies 3,200 lightyears away and spans approximately 20 lightyears. ☐ **SEEN IT**

2. M46 and M47

10x50 This contrasting pair of clusters lie together in the same field of view, 5° to the south of mag. +3.9 Alpha (α) Monocerotis. You should easily be able to resolve over half a dozen stars in M47. M46 is over three times as far away at 5,500 lightyears, but is a similar apparent size. It's larger and contains many more stars than M47, but you probably won't be able to resolve any of them. ☐ **SEEN IT**

3. M41

10x50 M41 is 4° south of Sirius and is visible to the naked eye. It appears larger than our previous clusters, and with 10x50 binoculars you should be able to resolve up to 10 brighter stars against the background glow of fainter stars if you use averted vision. If the sky is transparent enough, you may be able to detect differing star colours, with the brightest one, near the centre, being somewhat orange. ☐ **SEEN IT**

4. Omega Canis Majoris group

10x50 Mag. +4.0 Omega (ω) Canis Majoris lies 1.5° east of mag. +1.8 Wezen (Beta (β) Canis Majoris). It's a brilliant white compared to the fainter yellowish star that is just to the south of it. Both are part of the very attractive C-shaped 'dog's tail' of stars of varying colour that extends from mag. +5.9 26 Canis Majoris in the north, through 27 Canis Majoris and Omega Canis Majoris, to a mag. +5.4 yellow star 1° south of Wezen. ☐ **SEEN IT**

5. NGC 2362 and UW Canis Majoris

15x70 Use the chart to locate the brilliant blue-white mag. + 4.4 Tau (τ) Canis Majoris at the centre of the very tight open cluster NGC 2362. The slightly fainter, but otherwise similar, UW Canis Majoris lies less than half a degree north of Tau. However, every 4.39 days the brightness falls by half a magnitude from +4.8 as this blue supergiant is eclipsed by its fainter, smaller companion. ☐ **SEEN IT**

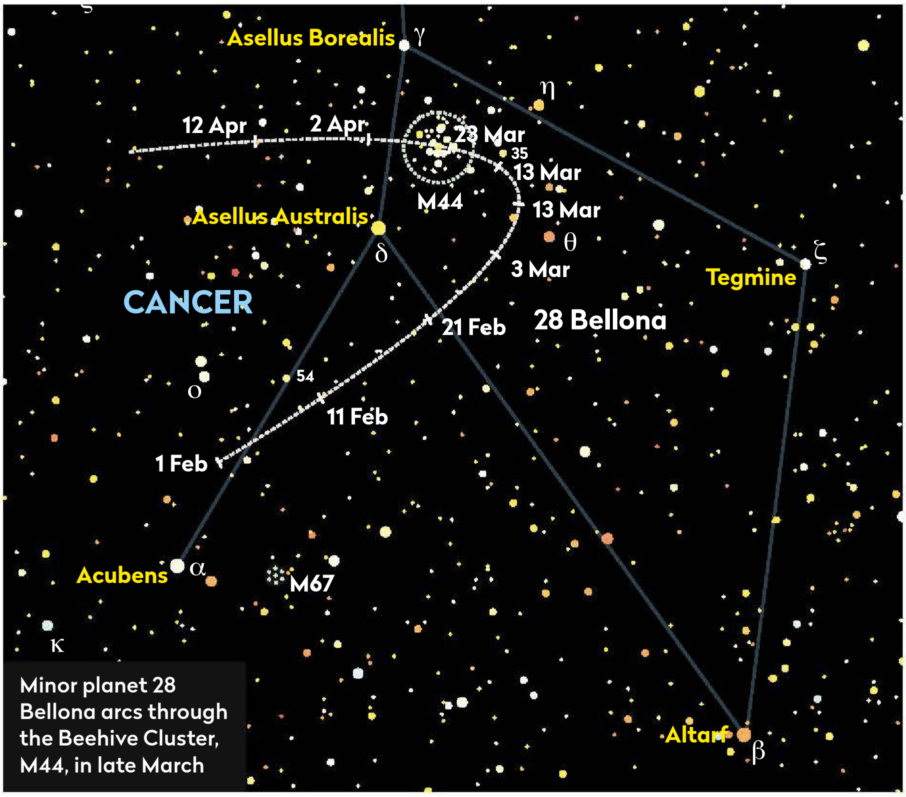
6. The 'Winter Albireo'

15x70 With UW Canis Majoris near the bottom of the field of view, you'll see a contrasting yellow star near the centre. This is the 'Winter Albireo', mag. +4.8 HD 56577. This star-party piece looks similar to the summer favourite Albireo (Beta (β) Cygni). A close double, at 27 arcseconds apart, it's tighter than its summer cousin so use 15x70s to separate it from its mag. +5.8 white companion. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

THE SKY GUIDE CHALLENGE

Can you photograph an asteroid crossing a star cluster? It's not as simple as it sounds



Minor planet 28 Bellona arcs through the Beehive Cluster, M44, in late March

There are a lot of asteroids in the Solar System, plenty of which are visible through small telescopes. It's therefore unsurprising that some will, from time to time, appear to pass across extended deep-sky objects like star clusters. This month's challenge is to track a couple of these interesting events coming up over the next few months.

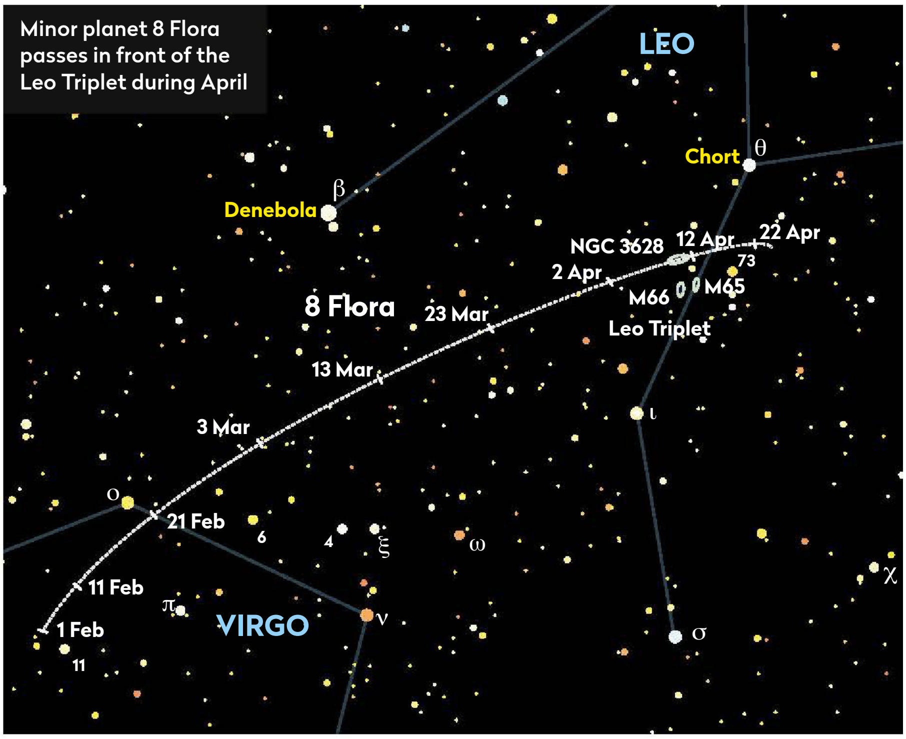
The first is to locate asteroid 28 Bellona. At the end of February, this 100km object will appear relatively near the Beehive Cluster, M44, in Cancer, the Crab. If you can locate it during February, shining at mag. +10.1 against the background stars of southern Cancer, you should be able to get into the habit of keeping track of it as continues towards M44 during March.

It eventually appears to cross the cluster from the end of March into April, when it'll be dimmer at around mag. +11.5. As the Beehive is very easy to find midway between Regulus (Alpha (α) Leonis) and Castor (Alpha (α) Geminorum), locating 28 Bellona during its cluster-crossing period shouldn't be too hard. If you've never observed an asteroid passing through a star field before, this is a great place to start.

28 Bellona is not the only asteroid performing this trick either. Next month, 8 Flora will reach opposition, when it can be seen shining at mag. +9.6 against the stars of southeast Leo. Keeping track of Flora through March and into early April, you'll be able to watch as it passes through the Leo Triplet, a famous patch of sky containing the three relatively bright galaxies, M65, M66 and NGC 3628. At mag. +10.1, 8 Flora actually passes in front of NGC 3628, the Hamburger Galaxy, between 9 and 12 April.

Both events will make for great photo opportunities, especially if you start gathering images of each object now and compile them into an aligned composite designed to show how their individual dots track against the background stars and galaxies.

If you're an imager, you'll need to plan your field of view to cover the whole path of the asteroids. Weather will affect your observations, creating gaps in the capture sequence, but that's a reality of astronomy! The Moon will have an influence too, brightening the sky as it passes along the section of the ecliptic closest to the asteroids. So, what originally seemed to be a fairly simple exercise turns out to be a challenging project to keep all of the images similar enough in appearance to be combinable for the final composite – ultimately, a great training challenge to improve your observational and imaging skills.



Minor planet 8 Flora passes in front of the Leo Triplet during April

DEEP-SKY TOUR

We're roving east of Sirius for delightful galaxies, clusters and planetary nebulae

1 M48

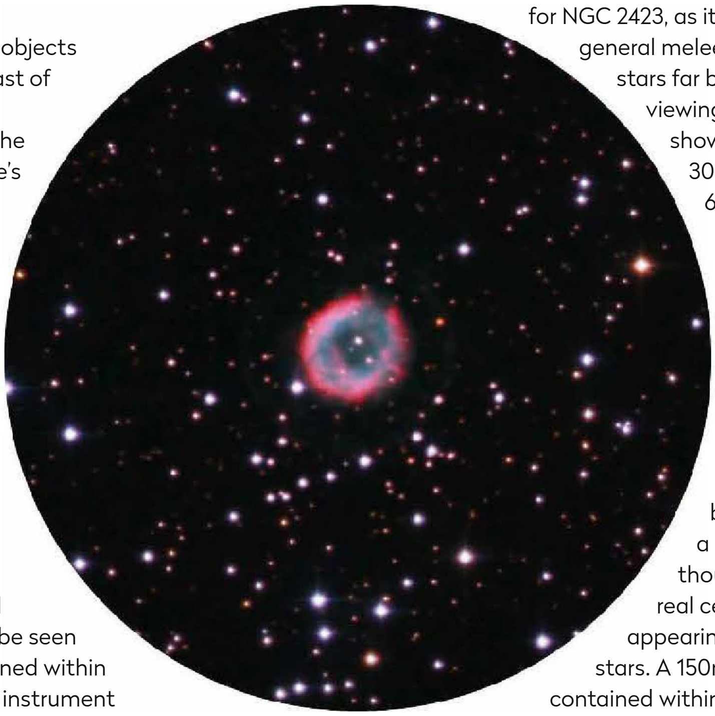
This month's tour looks at objects in the area immediately east of Sirius. We start with M48, a fine example of an open cluster on the Hydra–Monoceros border. There's not much to guide you to its location, although extend the line from Gomiesa (Beta (β) Canis Minoris) through Procyon (Alpha (α) Canis Minoris) for 3.3 times that distance again and you'll arrive at M48. Messier recorded the cluster's position incorrectly and sometimes discovery credit is attributed to Caroline Herschel in 1783. The cluster is bright at mag. +5.8 and looks great through a small telescope. Around 50 stars can be seen through a 150mm scope, contained within a 40-arcminute area. A 250mm instrument doubles the count and shows a general elongation to the cluster's shape. ☐ **SEEN IT**

2 M47

Head 12° southwest from M48 to arrive in the general vicinity of open cluster M47 in Puppis. Like M48, Messier's positional accuracy was off for this object too and for a while M47 was considered a lost Messier. Amazingly, the error was only realised by the Canadian astronomy TF Morris as recently as 1949. M47 has an integrated magnitude of +4.4, making it easily visible to the naked eye. A 150mm scope shows a more concentrated object than M48, containing 50 stars in an area 30 arcminutes across. Initial appearances show a mag. +5.7 star to the west, a mag. +6.5 star to the east and a tight triangular pattern at the cluster's centre which helps delineate M47 from the background Milky Way. ☐ **SEEN IT**

3 NGC 2423

If you've found M47, the next target is easy to find 0.6° north. Slightly dimmer than M47 at mag. +6.7, NGC 2423 is a rich cluster showing around 25 stars in an area 15 arcminutes across. Many of the stars here are fairly dim, the brightest being mag. +9.1 TYC 5409-1854-1 at the cluster's centre. This proves to be more of an issue for NGC 2423, as it tends to blend in with the general melee of background Milky Way stars far better than M47. Despite this, viewing the cluster at low power shows its concentration well. A 300mm scope reveals around 60 member stars. ☐ **SEEN IT**



▲ **Two for one: once you've found M46, you'll also have NGC 2438 (above), the planetary nebula embedded in its northern edge**

RUDOLF DOBESBERGER/CCDGUIDE.COM

4 M46

In the sky, M47 pairs nicely with its Messier catalogued neighbour M46, the latter being 1.3° east and slightly south of M47. M46 is fainter, its integrated mag. +6.1 brightness just dropping below naked-eye visibility from a dark site. It's a rich cluster though and, unlike M47, shows no real central condensation at all, appearing more like a misty haze of stars. A 150mm scope reveals 75 members contained within a 25-arcminute area. Again, it's worth looking at this region using a low-power eyepiece and moving your view back and forth between M46 and M47. The uniformity of the faint stars in M46 is really rather striking. ☐ **SEEN IT**

5 NGC 2438

If you're looking at M46, you're guaranteed to have found our next target, planetary nebula NGC 2438, because it's inside the cluster! Well, technically this isn't exactly correct as M46 is 5,000 or so lightyears away and Gaia measurements place the central star in NGC 2438 at 1,370 lightyears, making the planetary a foreground object. From Earth, it appears as a 1-arcminute disc in the northern part of M47. At mag. +10.8, you can glimpse it with a small telescope, but you'll need a larger aperture to show its shape convincingly. M47 and NGC 2438 make a great astrophotography target, smart scopes revealing the presence of the nebula very well. ☐ **SEEN IT**

6 NGC 2440

Our final target is another planetary nebula. NGC 2440 is located 3.4° south of M46 and shines at mag. +9.4. It's not dissimilar in size to NGC 2438, with an apparent size of 1.2 x 0.7 arcminutes, although through amateur scopes the fainter outer regions aren't that easy to see. It is visible in smaller instruments, but requires more aperture to start revealing structure. A 250mm scope shows an elongated object roughly 30 x 20 arcseconds across, with a bright circular region at its centre. Its central star is mag. +14.3, requiring a 300mm or larger scope to see. Catalogued as HD 62166, this white dwarf is one of the hottest known. ☐ **SEEN IT**

This Deep-Sky Tour has been automated
ASCOM-enabled Go-To mounts can take you to this month's targets at the touch of a button. Find the Deep-Sky Tour file in our free Bonus Content online.

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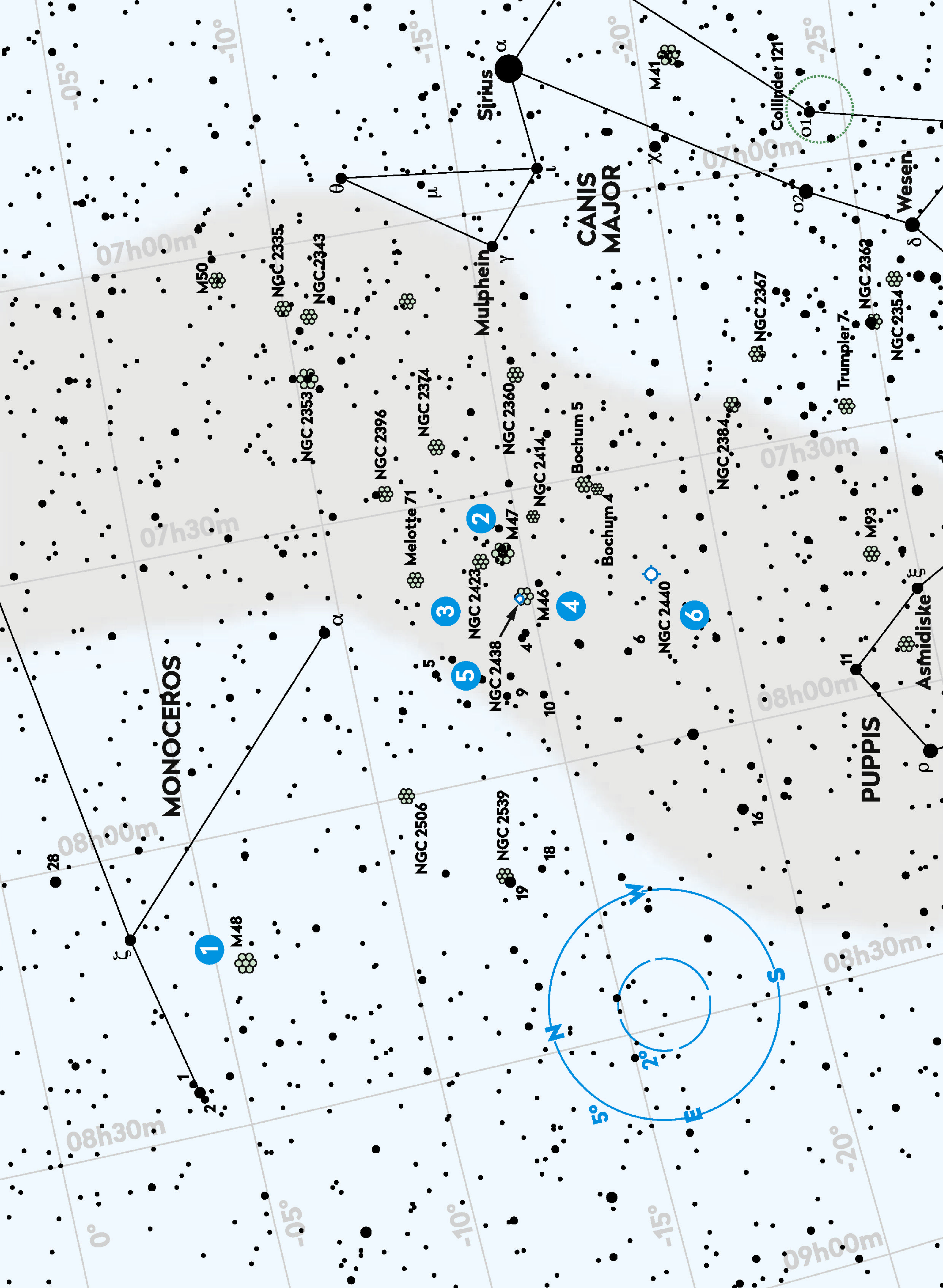
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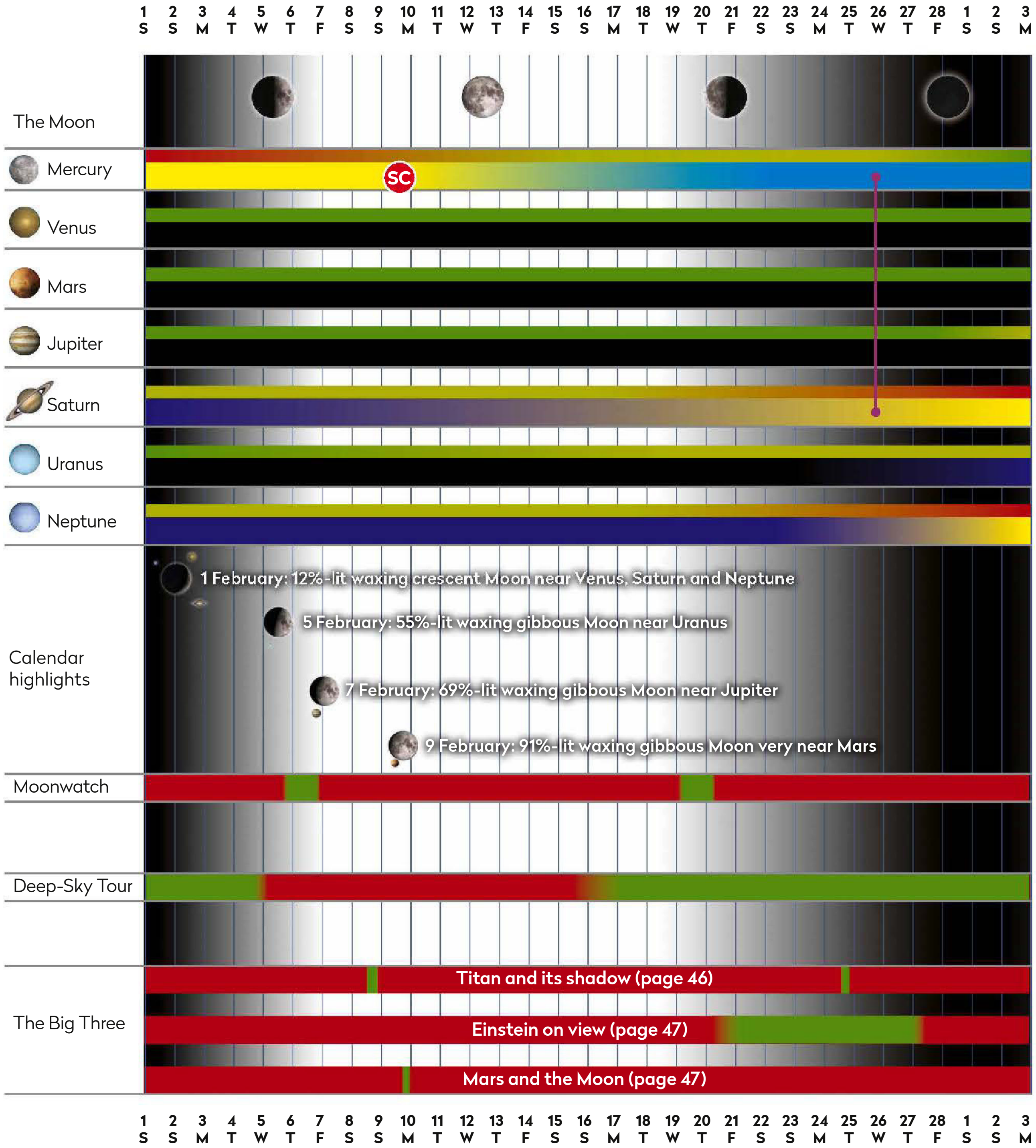
AT A GLANCE

How the Sky Guide events will appear in February



1 February: 12%-lit waxing crescent Moon near Venus, Saturn and Neptune

5 February: 55%-lit waxing gibbous Moon near Uranus

7 February: 69%-lit waxing gibbous Moon near Jupiter

9 February: 91%-lit waxing gibbous Moon very near Mars

KEY

Observability
🟩 Optimal
🟥 Poor

Best viewed
Morning twilight
Daytime
Evening twilight
Night

Sky brightness during lunar phases
Dark (first quarter)
Light (full Moon)
Dark (last quarter)
Total darkness (new Moon)

IC Inferior conjunction (Mercury & Venus only)
SC Superior conjunction
OP Planet at opposition
△ Meteor radiant peak
Planets in conjunction

Full Moon
First quarter
Last quarter
New Moon

CHART BY PETE LAWRENCE

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What to do if you find a meteorite

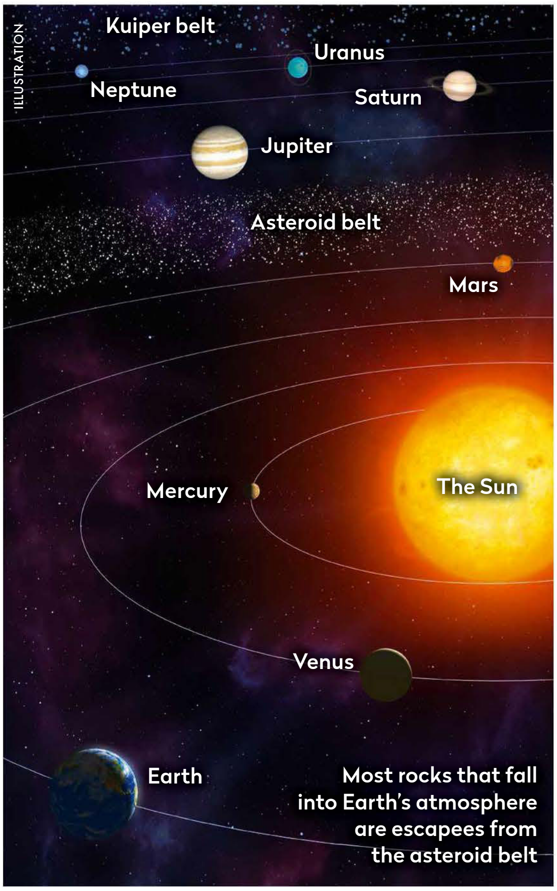
Ever come across an unusual rock and wondered if it's a meteorite? **Mark McIntyre** explains how to tell if that stone really is a fragment from outer space

We're all fascinated by meteorites, ancient stony visitors from outer space. But what exactly are they, how do they get here and how can you tell if you've found one?

Most meteorites are fragments of material left over from the time when the Solar System was forming. Some never got scooped up by the gravity of a newly created planet, so they're orbiting the Sun alone. Others ended up as part of an asteroid or in the nucleus of a comet. Some meteorites come from other planets, dwarf planets or moons, including lunar and Martian fragments that were ejected into space following an impact.

So you can see why these objects capture our imaginations. They offer us a chance to study the conditions of the early Solar System or the surface of another planet without having to go there. Indeed, meteorites are still the only samples we have from Mars or some of the dwarf planets like Ceres, so they are an invaluable source of information.

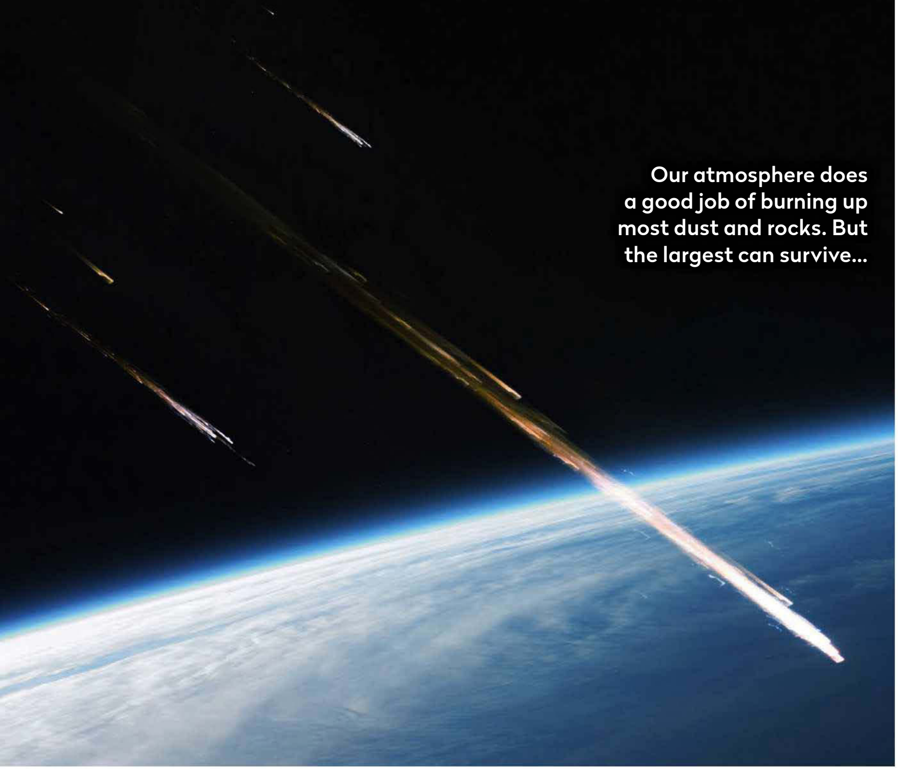
How do these fragments end up on Earth? Over millions of years, the gravity of the planets, especially Jupiter, has pushed asteroids into particular orbits, such as the asteroid belt between Mars and Jupiter. Collisions between asteroids create large fragments, small particles and dust, some of which get nudged into new orbits that take them towards Earth, where they burn up in our atmosphere to form a meteor. ▶



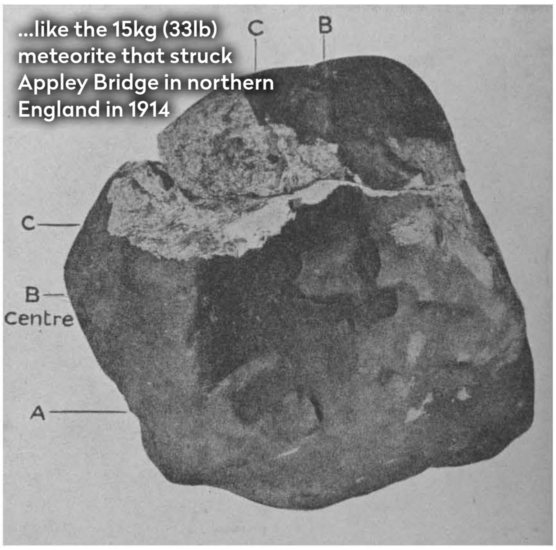
Most rocks that fall into Earth's atmosphere are escapees from the asteroid belt

MARK GARLICK/SCIENCE PHOTO LIBRARY/GETTY, WANG SHOUMING/500PX/GETTY

Thousands of space rocks head towards Earth every day – some even make it down to the ground as meteorites. But would you know how to recognise one if you found it?



Our atmosphere does a good job of burning up most dust and rocks. But the largest can survive...



...like the 15kg (33lb) meteorite that struck Appley Bridge in northern England in 1914

▶ Comets that formed far beyond the orbit of Neptune can also be nudged into new orbits that bring them to the inner Solar System. As a comet nears the Sun, its icy nucleus starts to sublimate, releasing a trail of trapped dust. When Earth passes through this dust, these particles will also burn up in our atmosphere as meteors. Cometary debris is responsible for most of our meteor showers.

What are the chances?

Every year, thousands of tonnes of dust and rock hit our atmosphere. On a clear night, meteor scientists in the UK record on average 1,000 meteors, with as many as 15,000 during a meteor shower. Most meteors are smaller than a grain of sand and travel very fast – between 50,000km/h and 300,000km/h (30,000–185,000mph) – so are usually completely burned up in the atmosphere. But if the lump of rock is big enough, some of it will survive and make it to the ground – a meteorite. Typically more than 99 per cent of the mass will be lost during flight, and objects weighing less than a few tens of grams are ablated completely, so a meteorite surviving to the ground is far more likely to be asteroidal rather than cometary.

You might be surprised to learn that as many as 10,000–20,000 meteorites reach ground level every year across the whole of Earth's surface. We might expect, then, one or two to fall on the UK per year; since 2020 there have been six organised meteorite hunts in the UK, of which one was successful.

This is why tracking fireballs with camera networks is so important. These cameras monitor the sky all night, every night. We can then combine their observations to find the meteor's location and velocity, often to within a few metres. This lets us do 'dark-flight modelling', where information about the weather and wind is used to work out the meteor's path after it cooled and faded from view. From this, the 'fall zone' can be calculated, which is where the meteorite might be on the ground. An official search can then be carried out.

It's important to be aware, however, that if you saw a fireball and then found an interesting rock in the vicinity, it almost certainly isn't a meteorite. Meteors are very high – at least 35km (20 miles) above ground level – and moving very fast, so a meteorite that survives burning up will continue to travel 50–200km (30–125 miles) from where it was last seen before landing. A recent fireball seen by cameras in Sussex, for example, dropped meteorites nearly 200km (125 miles) away in France.

Another thing to note is that most meteorites are small, usually the size of a pebble or small stone.

◀▲ One of the Canyon Diablo meteorites (left) from an asteroid that fell to earth 50,000 years ago, creating Meteor Crater in Arizona (above)

"You might be surprised to learn that 10,000–20,000 meteorites reach ground level every year across Earth's surface"

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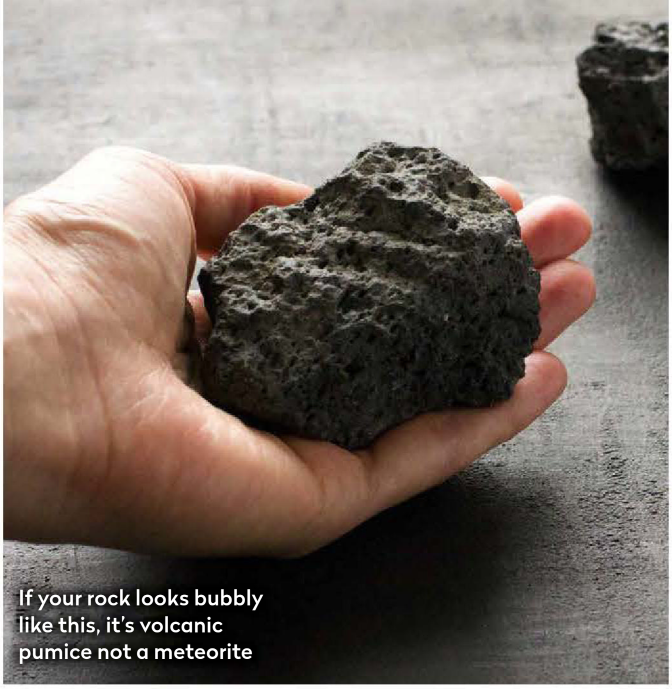
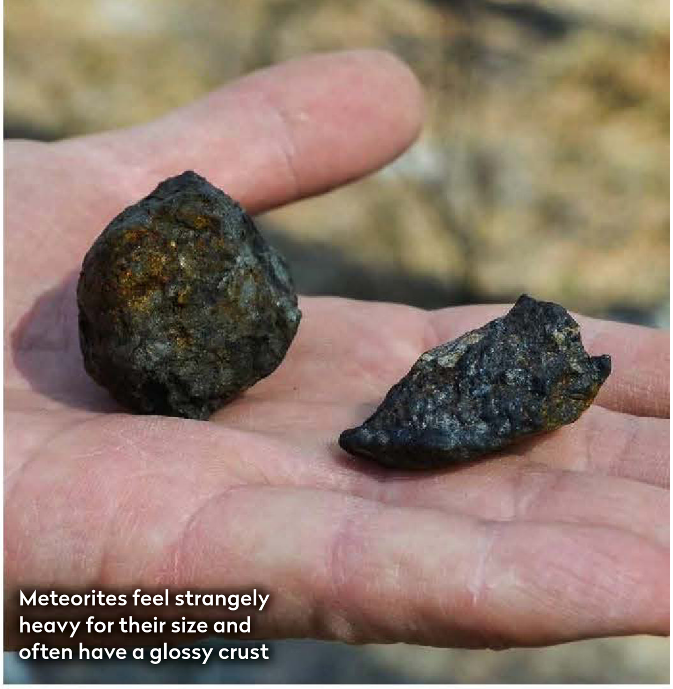


If your rock looks bubbly like this, it's volcanic pumice not a meteorite



Meteorites feel strangely heavy for their size and often have a glossy crust

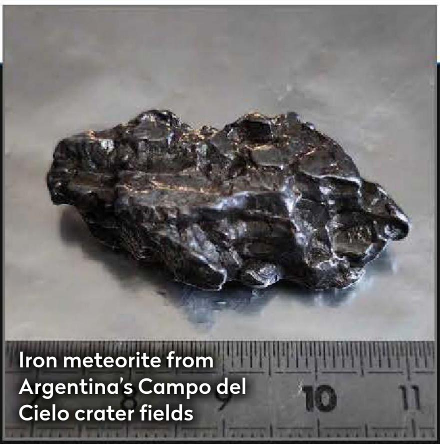
Because of this, they don't create impact craters and are usually found just resting on the ground. Of course, a big one like the 15kg (33lb) Appley Bridge meteorite, which landed in Lancashire in 1914, will create a bit of a splash – it was found 45cm (18 inches) under ground – but that's very rare.

Characteristics to look for

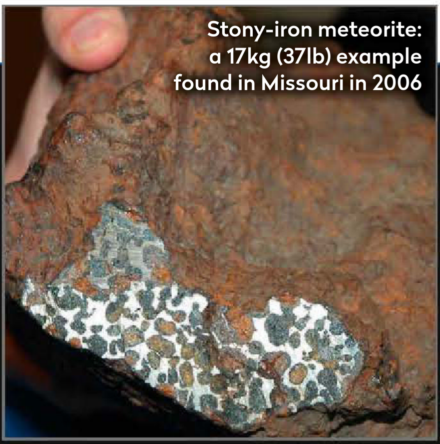
So, here are a few things to look for that will help you separate meteorites from meteor-wrongs.

Meteorites are usually black or brown, with a smooth, rounded surface, a bit like a piece of charcoal or smokeless coal. They often, but not always, feel heavy for their size, although this is also true for some terrestrial rocks like hematite and magnetite. Most meteorites also have a thin, glossy, fusion crust, which may be broken in places and may have dimples called regmaglypts; these look as if someone has pressed their thumbs lightly into them. Finally, the inside might appear lighter than the outside.

Meteorites never contain holes or have a porous or bubbly appearance, and they never have features that look like they've flowed. These indicate volcanic pumice, concrete or foundry slag. ▶



Iron meteorite from Argentina's Campo del Cielo crater fields



Stony-iron meteorite: a 17kg (37lb) example found in Missouri in 2006

Stony meteorites divide into two types: chondrites and achondrites

Know your meteorites

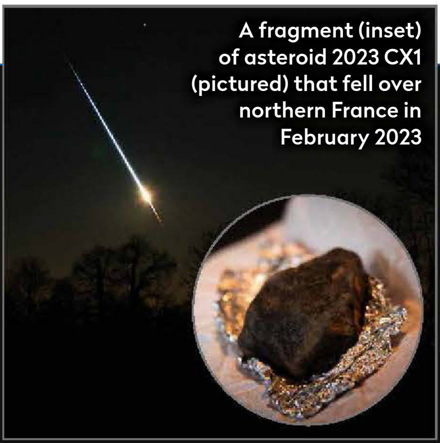
Meteorites are grouped into three classes depending on what they're made of

Iron meteorites are made mostly of iron and are believed to come from the cores of protoplanets that got smashed up in a collision. They're very heavy; even a small sample feels unusually heavy for its size. About 1,400 have been found and because they're very tough, there are lots of very large examples. Indeed, there are 50 samples weighing more than a tonne. There's a total of 580 tonnes of iron meteorites in collections around the world.

Stony-iron meteorites are rarer, with less than 300 ever found. They're made of a mix of stone and iron, and most are believed to have formed at the boundary between the core and mantle of a protoplanet that broke up in a collision. A few may have formed in collisions between iron and rocky fragments. Externally, they look a bit like concrete, but cross-sections reveal crystals embedded in iron.

Lastly, **stony meteorites** are made from rocky silicates. There are two main sub-types: achondrites which are meteorites from other planets; and chondrites, which are material from the formation of the Solar System. Chondrites often look like lumps of coal and are about as strong. They contain chondrules, little spherical globules of material that condensed out of the pre-Solar nebula. The rarest chondrites, carbonaceous chondrites, contain organic materials. Although there are over 27,000 stony meteorites in collections around the world, the total mass is only 90 tonnes because they're smaller and lighter.

Part of the Winchcombe meteorite in London's Natural History Museum


A fragment (inset) of asteroid 2023 CX1 (pictured) that fell over northern France in February 2023

The 810g Tekapo meteorite found after a fireball over New Zealand

Remarkable meteorite finds

Three recent search-and-rescue missions that got meteorite hunters excited

The most recent meteorite to fall in the UK is the Winchcombe meteorite. The fireball over Gloucestershire was captured on cameras in February 2021. It was found to be a rare carbonaceous chondrite and so of great scientific interest. Its track and fall zone were determined from data collected by a dozen cameras, but Covid restrictions meant special government permission was needed to search for it.

Another recent find is the CX1 meteorite in Normandy, France in 2023. A rare stony-iron meteorite, it is one of only seven meteorites whose parent body was seen before impact, as it was detected by astronomers seven hours before entry into the atmosphere. This allowed an international team to track and photograph it using cameras in the UK and France. The data was analysed by teams in UK, Canada and Australia and the analysis was passed on to French scientists, with meteorites being recovered a few days later.

Finally, there's the Tekapo meteorite, which fell over New Zealand in March 2024. This chondrite meteorite was also found using camera data and once again the analysis was an international collaboration. Remarkably, using the data the search party then took less than half an hour to find the meteor on the ground.

All these meteorites fell recently and were found quickly. This is very important because it meant they had not been exposed to Earth's weather for long and were in great shape for science.

◀ The Natural History Museum has a large collection of meteorites, including rare specimens that originated on Mars

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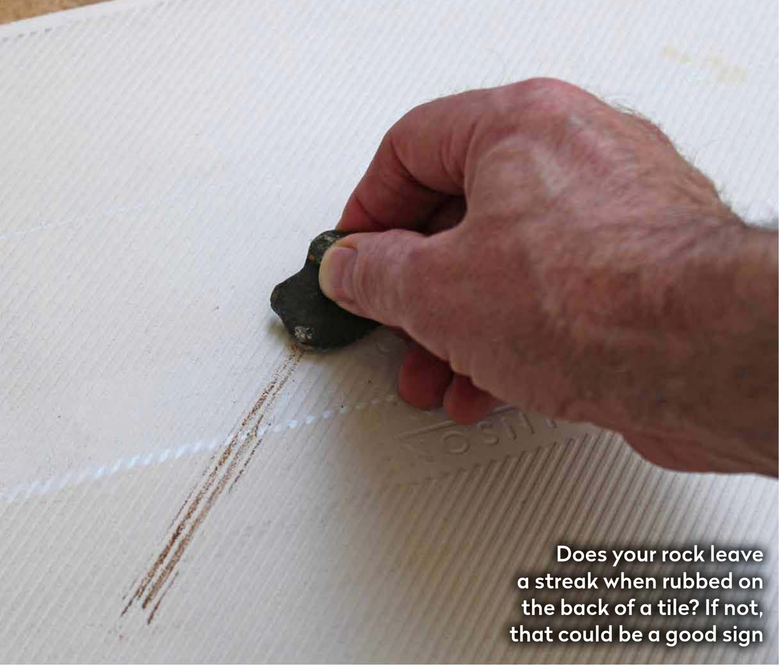
▶ Meteorites are also never reddish in colour, which indicates iron-rich rocks like hematite and magnetite, and they never have stripes or veins of crystals, which are features of terrestrial metamorphic rocks or granites. They also never contain quartz or calcite, which come from limestone and granite and aren't found in space. And of course they never, ever contain fossils!

One useful test to carry out is the 'streak test'. Rub a corner of the sample across the unglazed back of a ceramic tile. If it leaves a coloured streak, it's not a meteorite. However, some terrestrial rocks such as granite don't leave marks either, so the absence of a streak does not confirm that you have a meteorite.

One thing you shouldn't do is test the rock with a magnet. There are many magnetic terrestrial rocks, so this isn't a good test, but more importantly, if it *is* a meteorite, the magnet will damage its delicate internal magnetic structure.

Think you've got one?

If after going through these tests you feel sure that you've found a meteorite, you should send photos of your discovery or take it to your nearest



Does your rock leave a streak when rubbed on the back of a tile? If not, that could be a good sign

Avoid handling your sample excessively. PIck it up with a sandwich bag and seal it to avoid contamination

Include a ruler in all your photos before you send them to your nearest geology museum

geology or natural history museum for proper identification. Here they can carry out chemical and spectroscopic analysis, looking for specific markers of an extraterrestrial origin, such as isotopes that are not present on Earth and the relative abundances of silica, iron and magnesium oxides and other minerals. For example, stony meteorites always have around 40 per cent silica and 55 per cent iron and magnesium oxides, which is very different to most terrestrial rocks.

To help them with that assessment, here's what you should do:

▶ Take a photo of the meteorite where you found it, ideally before moving it, so you have a record of what it looked like on the ground. If your camera supports geotagging, switch this on so you can get a precise location. Otherwise, use a mapping app to get the location accurately. This is a really important step for the identification of the meteorite and can be linked to reported meteor sightings.

▶ Try to handle the meteorite as little as possible. The ideal way to collect it is using a clean, inside-out sandwich bag as a glove. Pick up the object, then turn the bag the right way out again with the object inside. Seal it and put it inside a second bag. This avoids contamination and keeps air and moisture out. Some meteorites are extremely fragile and can be permanently altered by water, so it's vital that you keep it dry. If you don't have a sandwich bag, aluminium foil can be used instead.

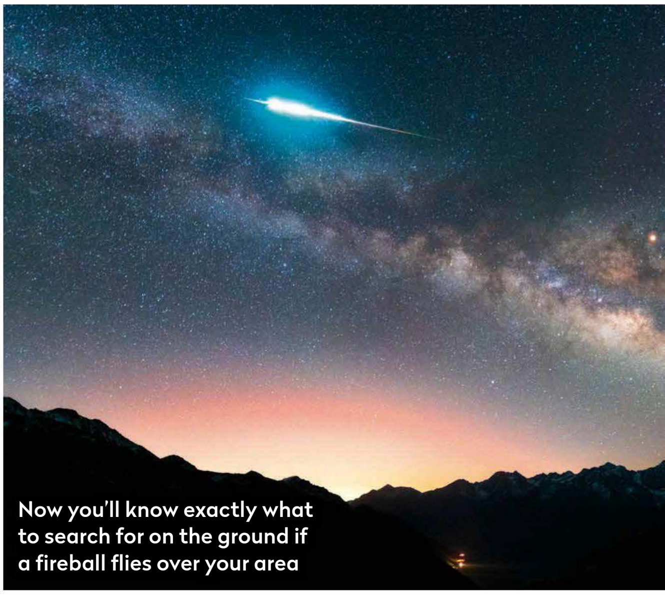
▶ Back at home, carefully tip out the sample onto a clean piece of foil on kitchen scales to weigh it, then place a ruler next to it and take photographs from several angles. Make sure that the photos are in focus and include the ruler!

▶ Bag it up again and send the photos and an explanation of where, how and when you found it to your nearest museum.

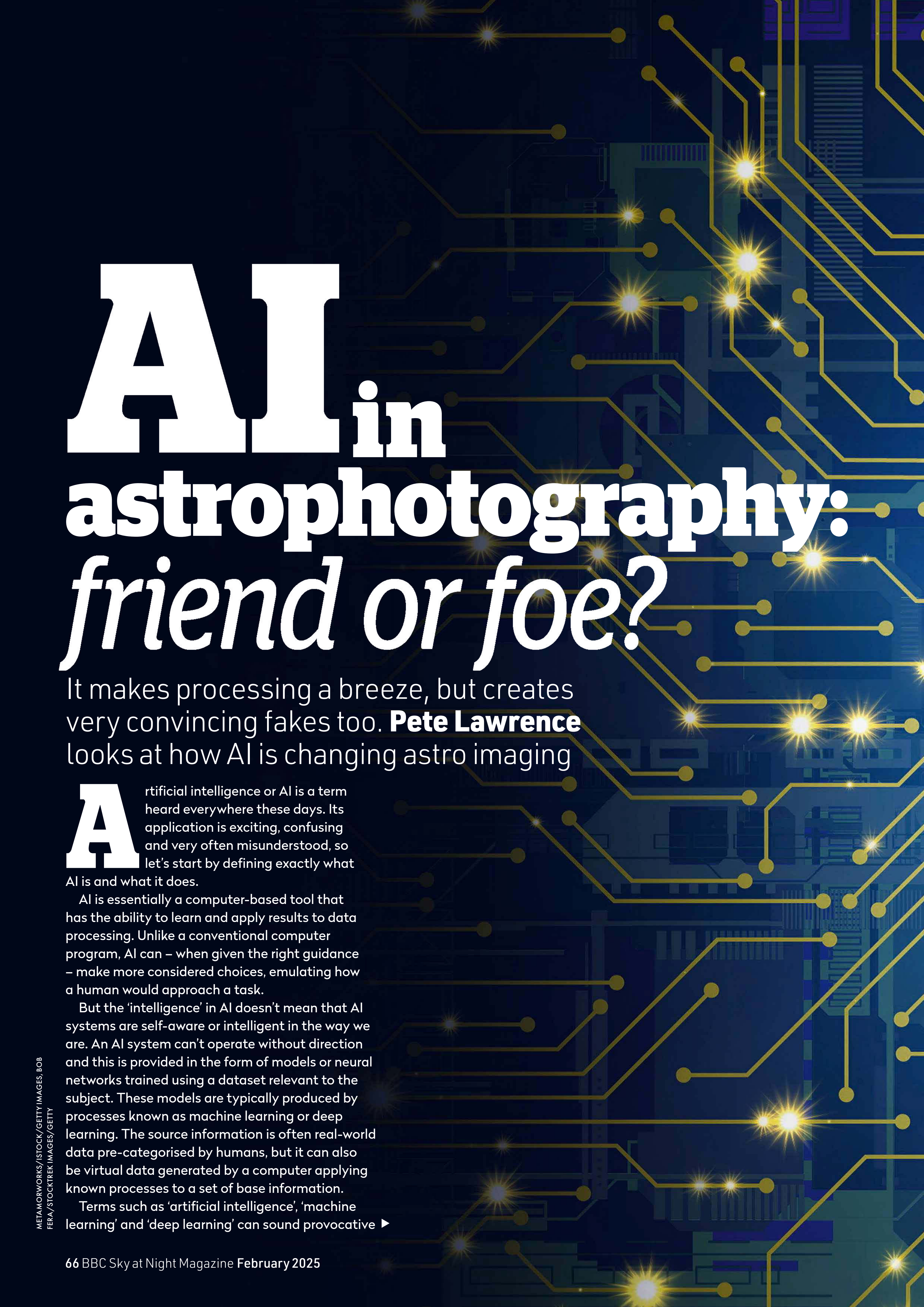
Good luck and happy meteorite hunting!

> *"Take a photo of the meteorite, ideally before moving it, so you have a record of what it looked like on the ground"*

Mark McIntyre is an astrophysicist, meteoricist and astrophotographer, and a member of the UK Meteor Network



Now you'll know exactly what to search for on the ground if a fireball flies over your area



AI in astrophotography: *friend or foe?*

It makes processing a breeze, but creates very convincing fakes too. **Pete Lawrence** looks at how AI is changing astro imaging

Artificial intelligence or AI is a term heard everywhere these days. Its application is exciting, confusing and very often misunderstood, so let's start by defining exactly what AI is and what it does.

AI is essentially a computer-based tool that has the ability to learn and apply results to data processing. Unlike a conventional computer program, AI can – when given the right guidance – make more considered choices, emulating how a human would approach a task.

But the 'intelligence' in AI doesn't mean that AI systems are self-aware or intelligent in the way we are. An AI system can't operate without direction and this is provided in the form of models or neural networks trained using a dataset relevant to the subject. These models are typically produced by processes known as machine learning or deep learning. The source information is often real-world data pre-categorised by humans, but it can also be virtual data generated by a computer applying known processes to a set of base information.

Terms such as 'artificial intelligence', 'machine learning' and 'deep learning' can sound provocative ▶

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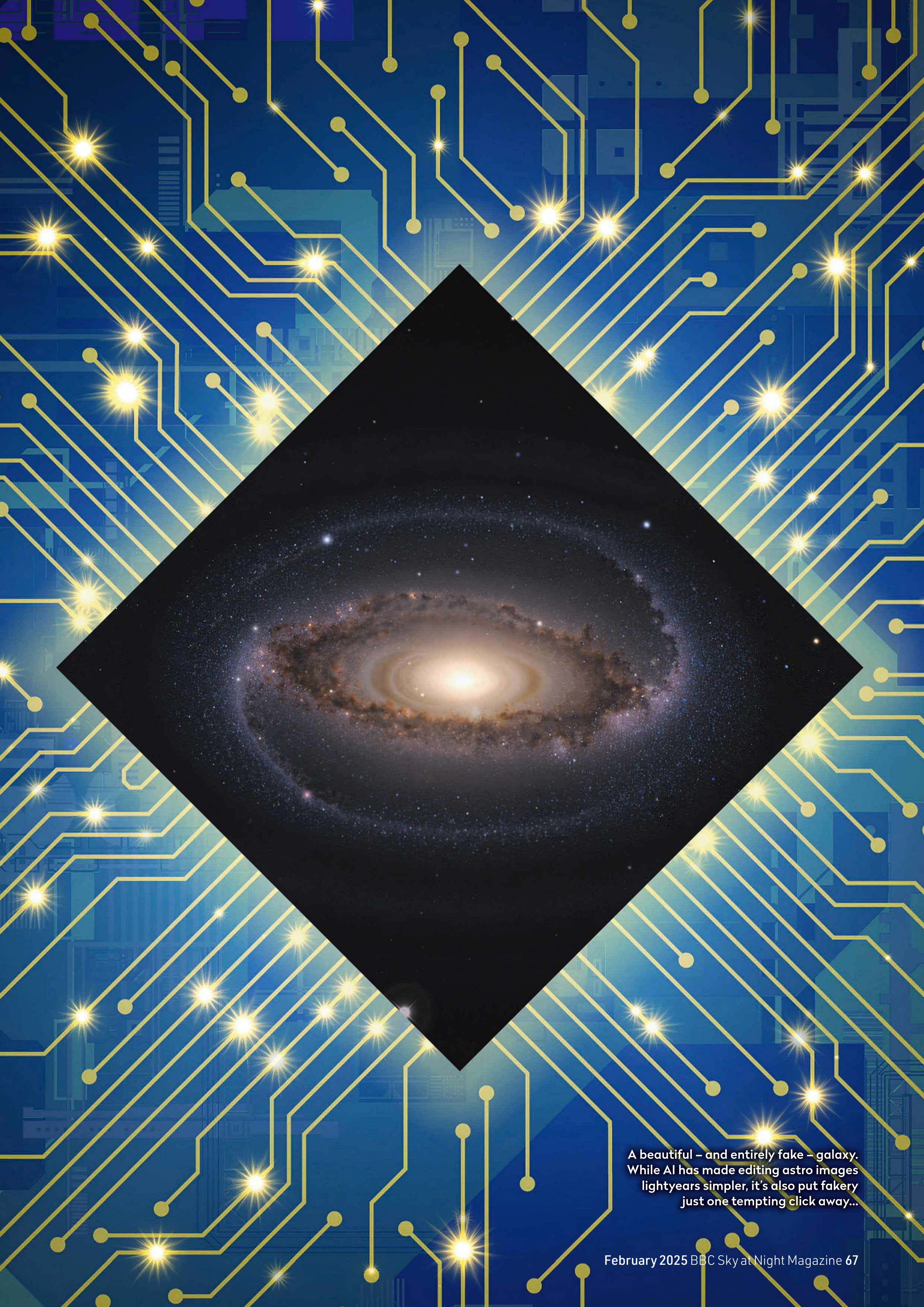
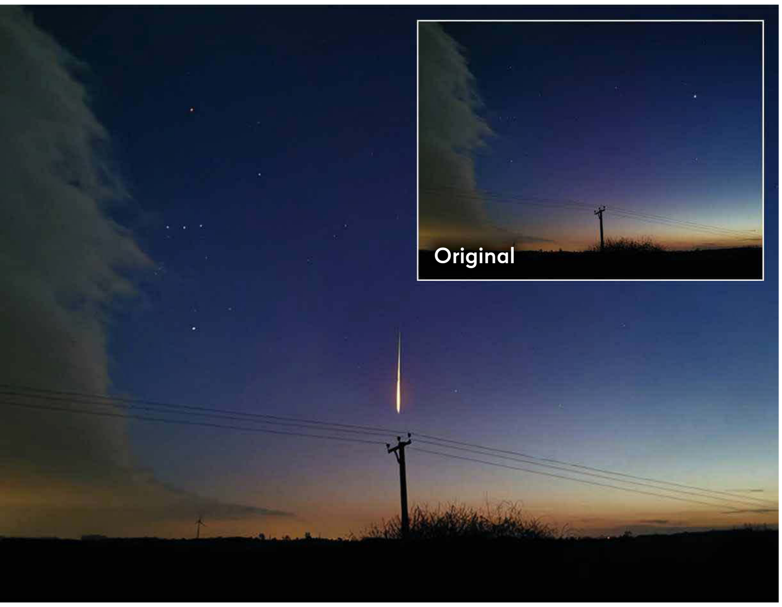
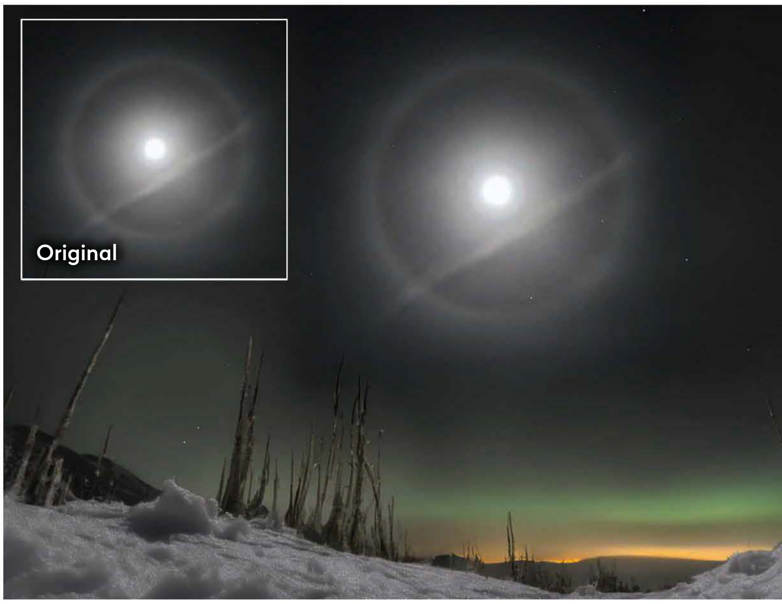


A beautiful – and entirely fake – galaxy. While AI has made editing astro images lightyears simpler, it's also put fakery just one tempting click away…





▲ **Above left: original sky (inset) and an 'inpainted' AI meteor trail Above right: original image of a lunar halo (inset) augmented by AI outpainting**

▶ but are merely references to what are essentially computer tools and systems. What's important to understand is that AI's abilities depend on how well-trained its models are. Poor or inappropriate model data will simply give poor results; the phrase 'garbage in, garbage out' is highly fitting to AI. Despite what Hollywood implies, AI is currently still dependent on humans to feed it the correct information in order for it to work efficiently.

Let's now look at some examples of how AI is being applied in astrophotography. On the internet, the inducement of social media 'Likes' has inevitably led to a rise in fake astronomical images. Many early attempts were poor manually edited examples, but skill levels have now improved, making some fakes hard to call out unless you're a skilled expert.

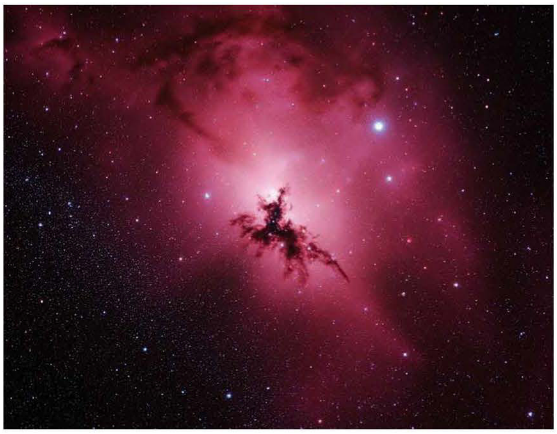
When algorithms make art

In the non-astro world, AI image generators have been developing at an amazing pace. Systems like Midjourney, DALL-E 3, Stable Diffusion and Flux can generate highly complex and realistic images from simple text prompts. Well-known commercial names like Adobe have also jumped on the bandwagon, introducing the ability to add AI-generated content to photos. Adobe's Firefly is a generative AI tool that adds this ability to Photoshop. 'Generative' simply means the system is able to produce original content based on user input, such as a text prompt (text-to-image) or another image (image-to-image).

Inpainting is a process that allows you to define an area within an existing image and request it be filled with AI content. Outpainting does the same but for regions outside the boundaries of an existing image. Wish that your beautiful shot of the Moon setting over the sea was in landscape format instead of portrait? No problem: just expand the canvas and request that it be outpainted.

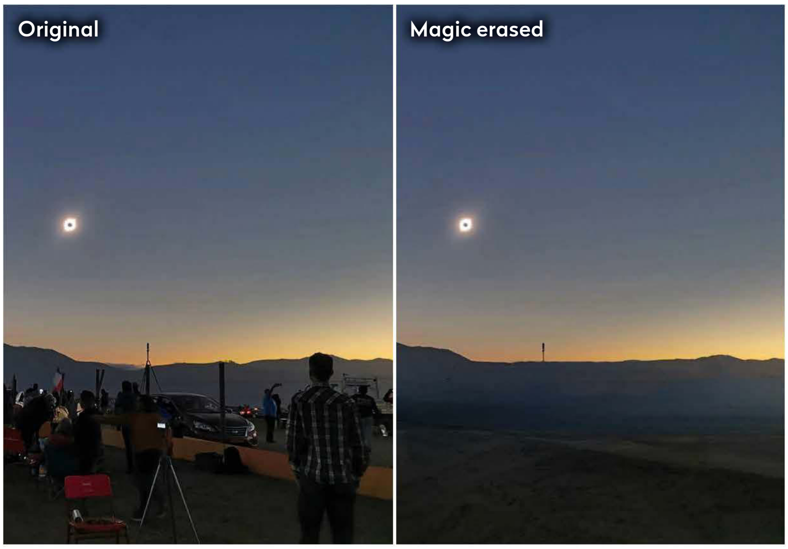
Does this mean that such systems can produce convincing fake astronomical images indistinguishable from the real thing? The answer depends on the subject. Current image-generation models are able to create images of nebulae, star clusters and galaxies, but without astronomical awareness. It will likely produce a decent stab at an astronomical object, but will locate it in a field of nonsense background stars. Real stars are key here, as they create a sky fingerprint that will unravel AI fakery. You do see AI deep-sky images on social media from time to time, some worryingly garnering

◀ **A detailed Moon, taken with a Huawei P30 smartphone. But is it real? Some phones add lunar features you didn't actually capture**



◀ **The non-existent nebula. No matter how realistic such images become, comparing to the real sky will always reveal a fake**

PETE LAWRENCE X 5, MRJUB/ISTOCK/GETTY, GRANT FAINT/ISTOCK/GETTY



▲ **I want to be alone! With the magic eraser feature, you can remove busy foregrounds in an instant**

thousands of Likes. It would seem the biggest issue is a lack of education or understanding, rather than the fake images themselves.

There's a problem looming, though. Other scenes can be faked quite convincingly. Head to social media and you'll find a mix of fake images that people think are real and real images that are called out as being AI. This is a worrying trend because it shows that AI is destabilising certainty.

Smartphones blur the picture

Smartphones are amazing devices. Driven by a saturated marketplace, manufacturers constantly try to woo customers by adding new functionality, and AI is now a big part of this. A few years ago, there was controversy over AI augmentation of Moon images. Some phones were taking hand-held images of the Moon using AI assistance to show amazing detail. But was the detail real?

Various tests were made by inquisitive owners which showed some background trickery going on. Rather than taking a photograph of the actual Moon, they tried taking one of a blurred lunar image on a computer screen. Some phones' AI modes then 'refined' the image, only to produce more detailed results than the original. Even blanking out certain areas of the Moon on the computer image resulted in phone images where the missing details were magically restored!

Google has been pushing AI image enhancement hard with its Pixel phones and the results are often impressive. For example, if you took a lovely photo of two bright planets in conjunction but subsequently realised you'd also captured a messy foreground, this is no longer an issue. Simply highlight the offending foreground detritus and the magic eraser effortlessly eradicates it for you. ▶

Spotting the fakes

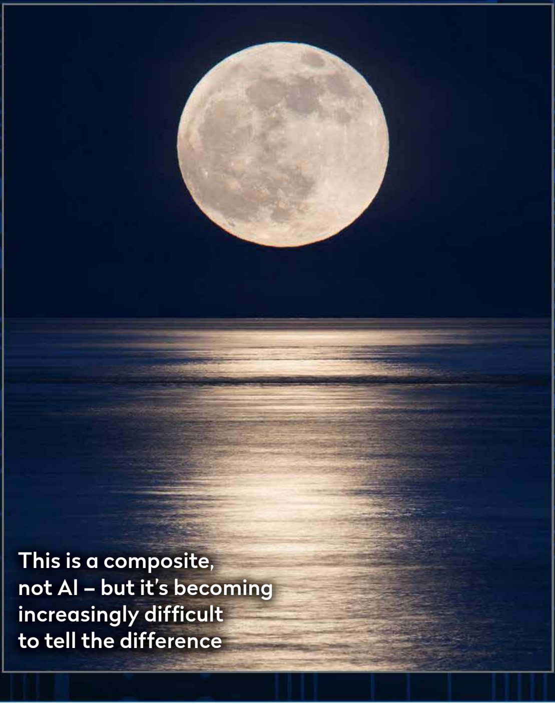
In nightscape images, AI's invisible hand can be hard to spot – even for the pros

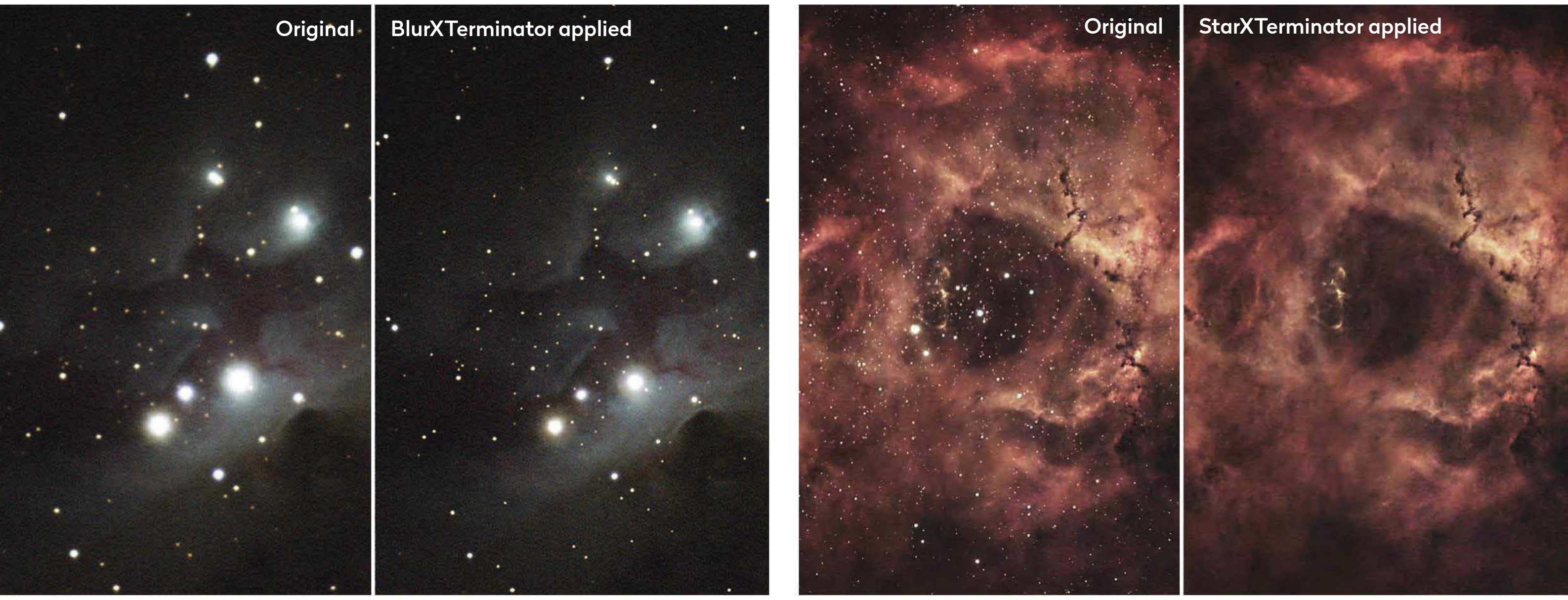
While deep-sky images can often be easily identified as fakes, nightscape astrophotography is far more vulnerable. How many times have you seen an image of the Moon rising above a mountain or reflected in a calm sea, and doubted it was real?

AI can be used to produce components of an image that can then be edited to produce a realistic composite. Depictions of transient events such as meteors or aurorae can be produced by AI quite convincingly, and combining these fakes with a real background star field or nightscape isn't hard to do. This means it now requires an expert eye to uncover fakes, though even then it can be tricky, posing a real issue for publishers, competition organisers and the science of astronomy as a whole.

"There were a series of photography competitions won by AI-generated images in 2022, and while none of the image generators were doing much to create convincing astrophotography, we knew it was only a matter of time," says Chad-Nadir Sciacca, project manager of the Astronomy Photographer of the Year Awards (see page 40), which has introduced new rules governing the use of AI.

"We had to be very careful not to inadvertently ban many everyday photographic and astrophotographic processing tools. Most editing suites now have some kind of machine learning built in, so it was clear early on that a blanket ban would not work. Instead, we have banned AI-generated data, and the new rules require all processing tools to be declared."


This is a composite, not AI – but it's becoming increasingly difficult to tell the difference



▶ What about AI tools specifically made for astrophotography? A number have appeared in recent years, targeting complex processing routines such as noise reduction, gradient removal and deconvolution. Here, the use of AI gets interesting because it opens up a whole can of worms.

The grey area of AI tools

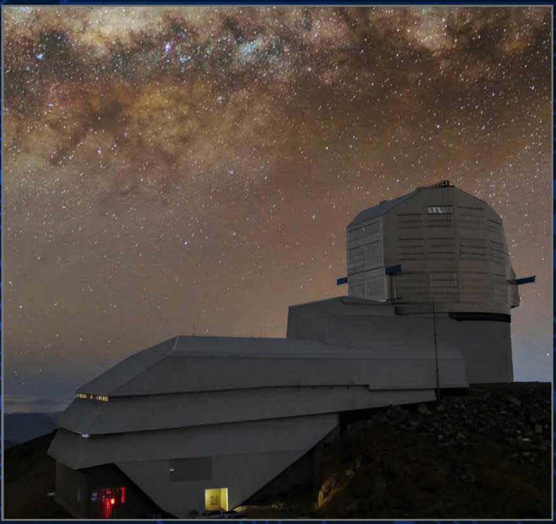
Astrophotography has always walked a tightrope between astronomy and low-light photography. Astronomy is a science requiring pure, preferably untouched data. The problem is that, in the amateur world at least, raw image data isn't always perceived as attractive. Consequently, the data normally undergoes lengthy processes before a final image is produced that convention dictates is worthy of displaying to fellow peers.

AI tools further muddy the water. The popular XTerminator add-ins for PixInsight from RC Astro – NoiseXTerminator, BlurXTerminator, GradientXTerminator and StarXTerminator – are highly regarded image-processing tools that use neural networks to achieve incredible results. Many astrophotographers use them without issue, but some cry foul, believing such processes create image data that wasn't in the original.

▲ Above left: BlurXTerminator is a powerful AI tool that can correct star shapes and sharpen up the features of deep-sky objects Above right: StarXTerminator does an impressive job of removing stars from an image, allowing you to work in isolation on what remains

Big data

For professional astronomers, AI is a game-changer for handling huge datasets



▲ The flood of data from Rubin Observatory in need of recognition, categorisation and analysis will be far beyond what humans can handle. AI will take the strain

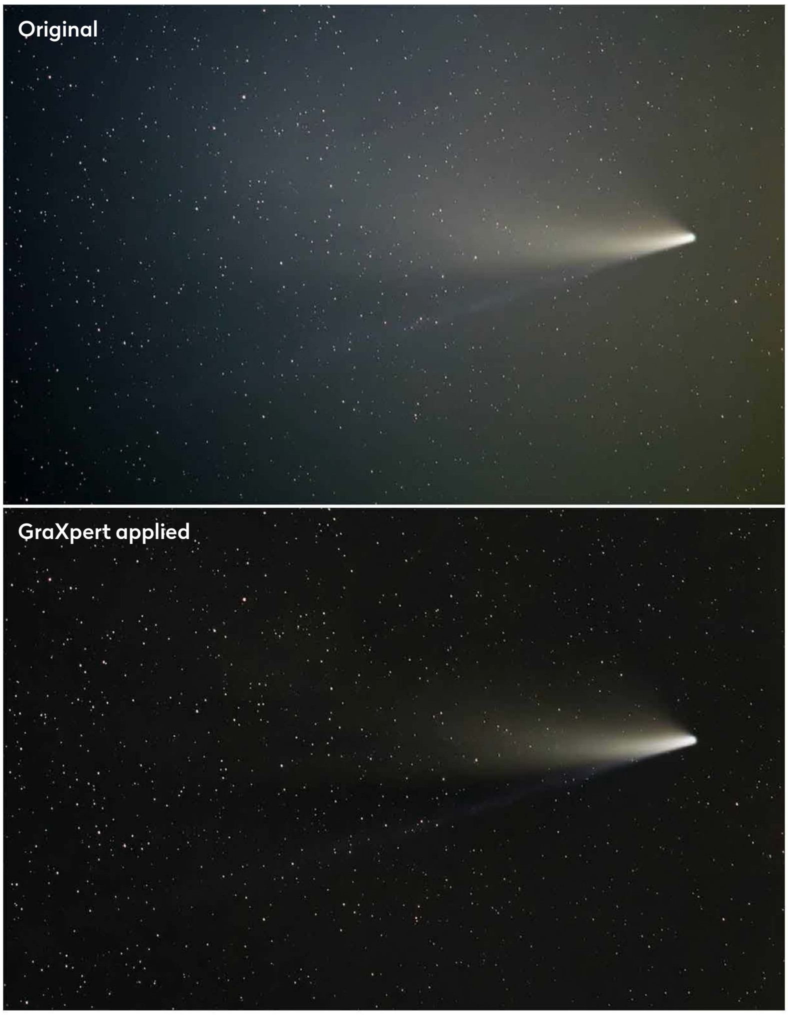
In the universe of professional astronomy, there's a tidal surge of data. The Vera C Rubin Observatory is expected to become operational early in 2025 and it's anticipated that this alone will produce around 60 petabytes (1 petabyte = 1 million gigabytes) of data over its 10-year survey period. JWST produces over 50 gigabytes of data every day.

Such huge amounts of information are overwhelming for humans to deal with. Here AI excels, able to recognise things such as faint light-curve dips, which reveal the presence of exoplanets orbiting their host stars, or detecting and classifying distant galaxies from the early stages of the Universe.

However, there's danger here too. Using trained AI to look for known patterns means it's not looking for unknown stuff. And it's within the unknown stuff that many major discoveries in astronomy and astrophysics have been made.

To counter this, untrained AI systems are also being used to look for patterns. Here, the AI has no idea what it's looking for and simply acts as a sieve, sending the interesting stuff for human interpretation. In addition, some systems simply look at patterns in the noise.

With the huge amount of data heading our way over the next few years, AI systems will study it tirelessly, looking for the expected and unexpected alike. It's really exciting to think about what they may find.

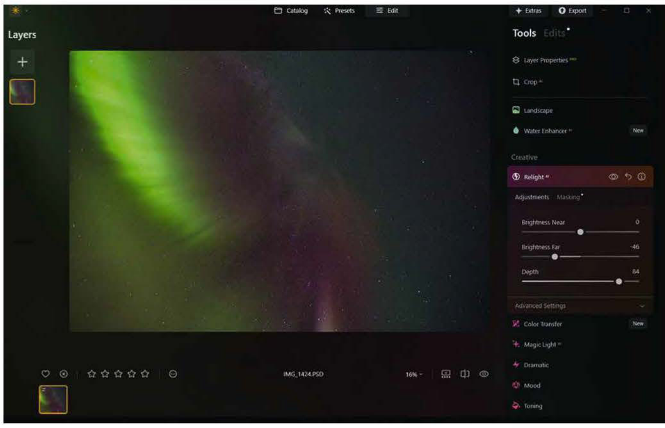


▲ Bad gradients in this comet image (top), confidently and instantly removed by the AI version of the free GraXpert tool

> *"There's always the little voice on your shoulder prompting you to go that extra bit further"*

Take BlurXTerminator, for example. It's a very powerful tool that can fix all sorts of image aberrations, things that purists claim should have been correct at the point of capture. The add-in performs a smart deconvolution on the original image using a trained model to correct errors appropriately across different parts of the image. And when applied correctly, it can do an impressive job, removing all sorts of issues and correcting bad star shapes.

Another popular tool is GraXpert, which now has an AI version. This is a freeware application designed for gradient removal. Gradients are messy variations in the background of an image, bright or dark areas that greatly affect the fidelity of the shot. They can be removed manually, but it's painstaking work. Advanced astrophotography image-processing systems like PixInsight have routines to help with their removal. Now with GraXpert AI, it can be done as well if not better for free.



▲ Luminar Neo is a fully featured editor with advanced AI options – how far you go with them is up to you

Crossing the line?

Luminar Neo (Skylum) is an application that is similar to Adobe's Lightroom, but with AI-enhanced functionality. It offers many ways to augment an image, but also many ways to create image enhancements that weren't in the original. It can change the appearance of the sky or colours in regular photographic images, but can also be applied to astrophotos. In this respect it's an interesting editor, because you are in control of how far you want to take adjustments. It can produce enhanced images true to the original, but there's always the little voice on your shoulder prompting you to go that extra bit further. Here, the burden of authenticity lies solely with you.

Topaz Labs produce many fantastic software products that have been used by many for years. In particular, their noise-reduction plug-ins for Photoshop have been the saviour of many a noisy astrophoto. Their direction now incorporates AI and, although very impressive, the end results are not compatible with astronomy as a science, as AI introduces levels of detail that look amazing in general photography but tread over the line where the data needs to be pure.

Whether we like it or not, AI is not going away. The images it generates or corrects will get better as models and processes are refined. How far you're willing to use the technology is up to you as an individual. Perhaps it's a good thing that the genie is now out of the bottle. Maybe AI will force the distinction to become clearer between true astronomical imaging for science, and low-light photography where the rules are more relaxed.

Pete Lawrence is an expert astro-imager and a presenter on *The Sky at Night*

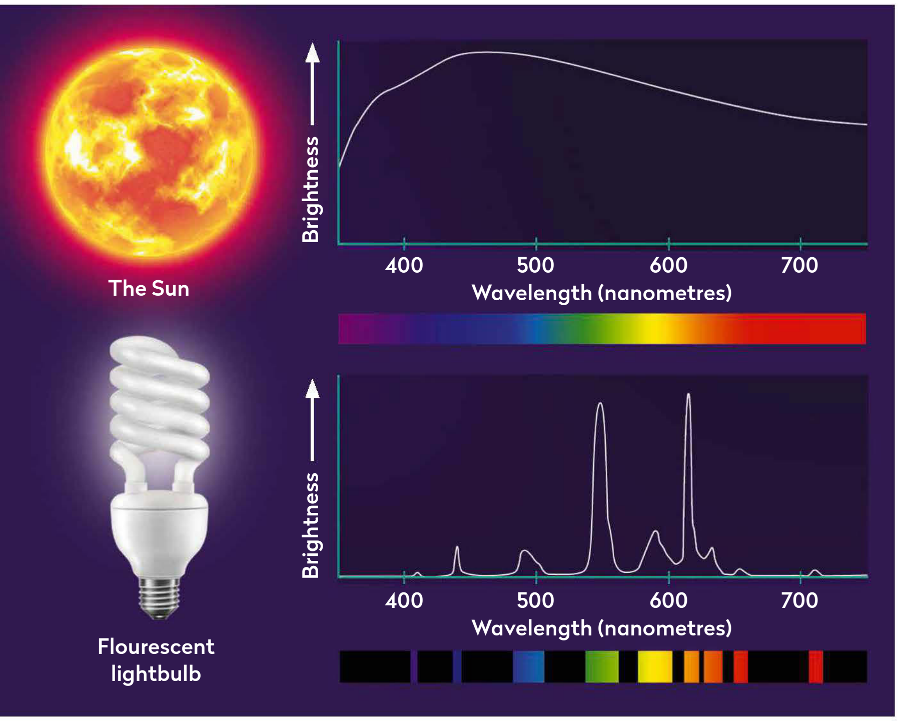
PETE LAWRENCE X 4, MRJUB/ISTOCK/GETTY, RUBIN OBSERVATORY/NOIRLAB/NSF/AURA/H. STOCKEBRAND

The fundamentals of astronomy for beginners

EXPLAINER

Spectroscopy

How we learn about stars, nebulae and planets by splitting and analysing their light



▲ Different light sources produce their own distinct spectra of colours. Astronomers can identify the chemical make-up, temperature, density and motion of objects in space from the colours of light they emit, absorb and reflect

A prism will spread white light into its constituent colours

Raindrops do the same, splitting sunlight into a spectrum

NASA/ESA/LEAH HUSTAK (STSCI), MEINDERT VAN DER HAVEN/ISTOCK/GETTY, VYASPHOTO/ISTOCK/GETTY, MARK PARRISH, NAZARII NESHCHERENSKYI/ISTOCK/GETTY, JWST: ALEX-MIT/ISTOCK/GETTY

Modern telescopes are capable of providing much more than mere images of distant objects. One of the biggest tools that astronomers use to study the Universe is spectroscopy, the science of splitting light (visible or otherwise) into its component wavelengths, known as a spectrum. Different materials reflect, absorb and emit light at characteristic wavelengths. This means that the object that emitted the light, plus any gas the light travels through and any surface it reflects off, all imprint a signature on the spectrum. We can study this signature to understand the properties of planets, stars, galaxies and nebulae.

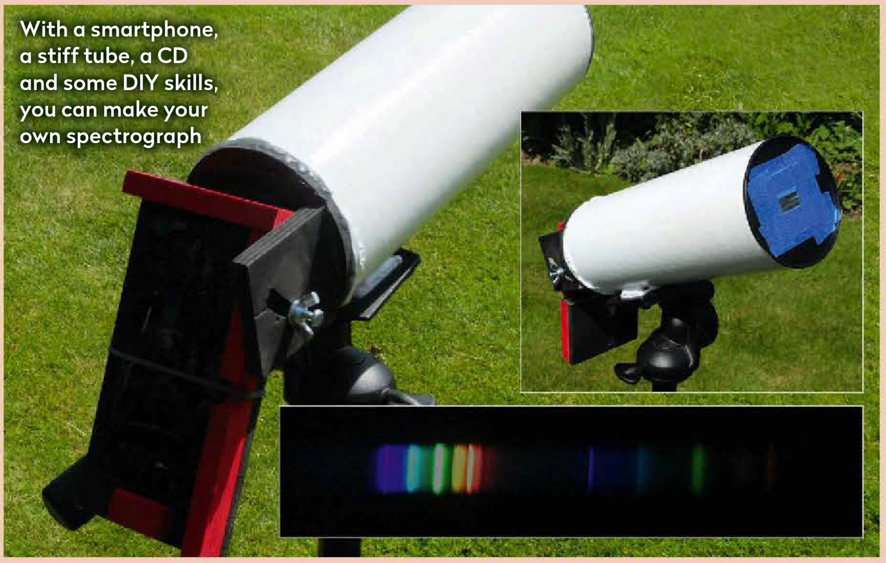
Instruments that split light like this are called spectroscopes or spectrographs, with the resulting spectrum typically plotted as the light's intensity against wavelength. These instruments can make use of a prism, whereby light entering the prism is bent (or refracted), with different wavelengths being bent by different amounts. Many may recall seeing this demonstrated in simple school science experiments, where white light is directed towards a prism. The light enters, is split and exits as a rainbow of colours, with shorter wavelengths towards the blue end and longer towards wavelengths the red. The natural rainbows we see in the sky are also created by the same process, with water droplets in the air acting as prisms to refract and split sunlight. As well as prisms, spectrographs can incorporate gratings, which use a process known as diffraction to split the light.

What colour can tell us

A key use of spectroscopy is to study the chemical composition of an object. When light reflects off an object, some wavelengths are absorbed by the surface and will therefore be missing, appearing as weak bands or dips in the spectrum we collect. The exact wavelengths absorbed will differ depending on the elements, molecules or minerals present in the material of the object – thus the spectrum provides a fingerprint of the surface's composition.

Spectroscopy at home

You don't need a huge telescope – a back garden setup can also do spectroscopy


With a smartphone, a stiff tube, a CD and some DIY skills, you can make your own spectrograph

Spectroscopy is surprisingly accessible to amateur astronomers. You can get started in the hobby by making your own spectrograph out of a CD and a cardboard tube (find the full details here: **bit.ly/CDSpec**). All you need to do is point the device at a bright light source, such as the Sun or a lightbulb, and the CD will act like a diffraction grating, splitting the light into a single rainbow line – the spectrum. You can either photograph this with a smartphone or look for yourself to see dark absorption and brighter emission lines striping through the rainbow colours.

If you wish to take a look at dimmer light sources, you'll need to purchase a special prism or diffraction grating, which look much like a traditional astronomy filter. When used with a telescope and astronomy camera, this lets you zero-in on a specific star, and then photograph the resulting spectrum. You can then use software such as RSpec, Visual Spec or ISIS to analyse the pattern of lines and uncover what elements are hiding in the starlight.

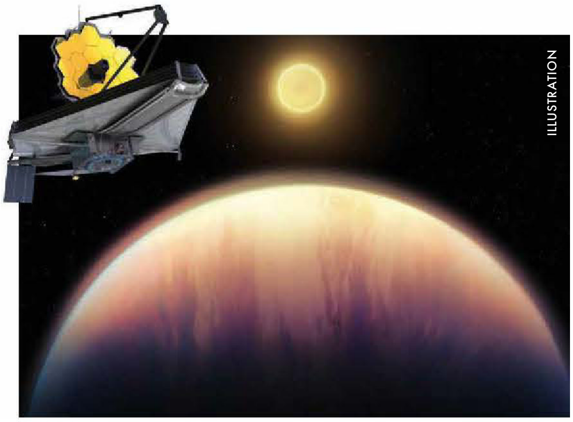
This is nicely demonstrated by considering the colour of objects around us. They appear a certain colour to our eyes depending on what they're made of and what wavelengths of light they reflect and absorb. For example, green leaves appear green because the chlorophyll they contain absorbs the blue and red wavelengths from sunlight, but reflects the green. Laboratory experiments have created databases of these characteristic spectra for a range of materials. Comparing the spectra we collect from celestial objects such as stars, moons and planets against these databases makes it possible for astronomers to remotely determine their composition.

A similar process happens when light travels through a cloud of gas. However, some clouds – such as nebulae – often *emit* light as well, creating spikes at certain wavelengths known as emission features. Indeed, for nebulae some emission features are so strong that astronomers can image the nebulae at those wavelengths, mapping the gases within them.

Spectroscopy can also be used to determine other properties of celestial objects. For example, the emission features of a star are dependent on its surface temperature, so can be used to measure this. What's more, if its brightness (luminosity) is measured, one can determine the size of the star.

Additionally, we can study spectra to reveal details of an object's motion relative to us. This is because motion towards or away from us results in the characteristic features in the spectrum being displaced from where they should be. When moving towards us, they are observed to be shorter (bluer) in wavelength, whereas when moving away they are observed to be longer (redder). Monitoring these 'Doppler' shifts over time, looking for small variations, can be particularly useful for astronomers studying stars, as this can indicate whether planets are present, gravitationally pulling and pushing the star towards and away from us during their orbits.

▶ Spectrographs on board the JWST allow us to interpret the atmospheres of distant worlds, including their potential for life



When such exoplanets (planets around other stars) are identified, high-resolution space telescopes like the James Webb Space Telescope (JWST) are even using spectroscopy to study the composition of their atmospheres and ultimately assess their potential habitability. Spectroscopy is therefore vital in our search for life beyond Earth. Indeed, it's one of the most useful scientific methods currently available to astronomers.

Penny Wozniakiewicz is a senior lecturer in space science at the University of Kent

Practical astronomy know-how for every level of expertise

SKILLS FOR STARGAZERS

Set up your first imaging sequence

How to automate and coordinate your gear over multiple nights of imaging

▲ **To gather the hours of data needed for targets like the Rosette Nebula, you can set your equipment up to run automatically for days or even months**

When imaging deep-sky objects, we take multiple long exposures, either using a DSLR or cooled astrophotography camera, with the aim of capturing many hours of sub-exposures to stack together.

The process of capturing this data, which can involve changing filters and star focusing, is called an imaging sequence and it can take days, weeks or even months to capture your chosen target. However, if you use items such as electronic filter wheels and autofocusers, this sequence can be automated using software that tells your equipment when to perform crucial actions such as locating the target, changing the filter or even making meridian flips. It can also ensure you return to the exact same patch of sky and continue imaging your deep-sky object over multiple nights – very useful if weather conditions interrupt your astrophotography sessions.

Sequence Generator Pro (SGPro) is a subscription-based software that connects to your equipment, including mount, camera and accessories like electronic autofocusers and filter wheels. It performs many handy functions, including slewing to and framing the target, checking the position and rotation of an image, and changing between filters.

Here I'll run through the process of selecting a target and setting up your equipment in SGPro so that you can create an imaging sequence. We'll use one of SGPro's most important features, its 'Framing & Mosaic Wizard'. To use this effectively, there are a few parameters that must be set depending on your equipment, including its image scale and the size of your camera sensor, considering your telescope and camera combination. You can use the field of view calculator at www.astronomy.tools to help find these.

Peter Jenkins is an astrophotographer and a fellow of the Royal Astronomical Society

ALL PICTURES: PETER JENKINS

Give your orders

Once these are added, your chosen target can be entered either as a catalogue number or name. SGPro then provides an image of the target area and you can drag your mouse over your selected area. The field of view of the sensor you've set will be shown, and the position and rotation of your capture can be adjusted before you click 'Create Sequence'.

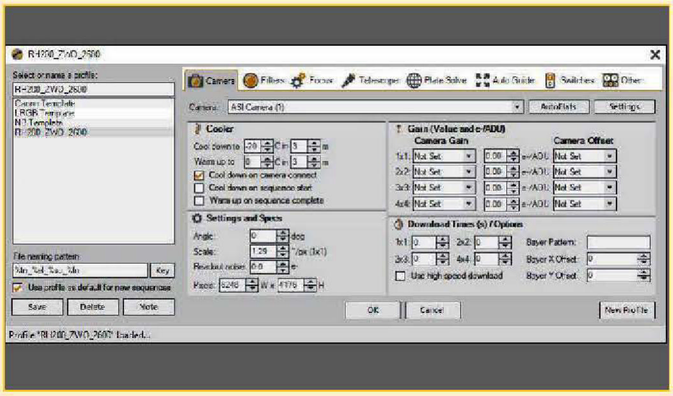
When the target has been confirmed, the Sequencer window is displayed to enter capture parameters. If you're using filters, you can set separate imaging runs for each one via the drop-down menu. Enter the number and length of exposures and a file destination for the subframes. Once your equipment is connected, your guiding software is running, your mount is unparked and the 'Run Sequence' button is pressed, SGPro automates everything.

It uses plate solving to slew to a target: the software compares a short exposure to a preloaded database of star positions and calculates exactly where the telescope is pointing. It can then automatically recentre by moving the mount to the target specified. Further exposures are taken, if necessary, to adjust your setup's position until the target is precisely centred. Guiding is paused during this process and restarted once the target is accurately positioned.

What you'll need

- ▶ An equatorial Go-To mount and a camera that can be controlled using software
- ▶ Cables to connect your equipment to your laptop or computer
- ▶ Guiding software, such as PHD2
- ▶ An SGPro subscription from www.sequencegeneratorpro.com
- ▶ ASCOM drivers for all your equipment
- ▶ SGPro utilises plate-solving software such as ASTAP or ANSVR, so one of these with the relevant star databases should be installed

Step by step



RH200_ZWO_2600

Select or name a profile: RH200_ZWO_2600

Camera: ASI Camera (1)

Cooler
Cool down to -20 C in 3 m
Warm up to 0 C in 3 m
☑ Cool down on camera connect
☐ Cool down on sequence start
☐ Warm up on sequence complete

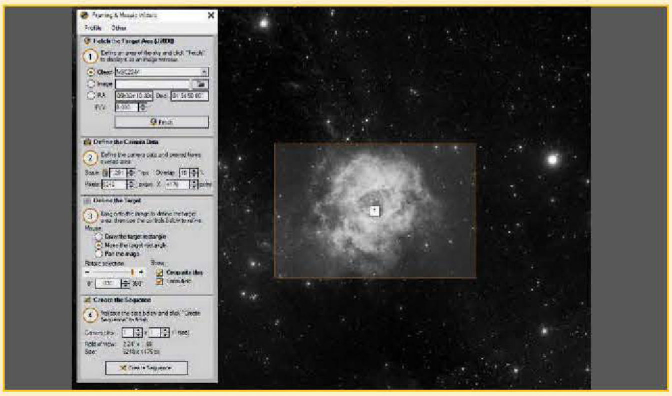
Settings and Specs
Angle: 0 deg
Scale: 1.29 "/px (1x1)
Readout noise: 0.0 e-
Pixels: 6248 W x 4176 H

File naming pattern: %tn_%el_%su_%fn
☑ Use profile as default for new sequences

Profile "RH200_ZWO_2600" loaded...

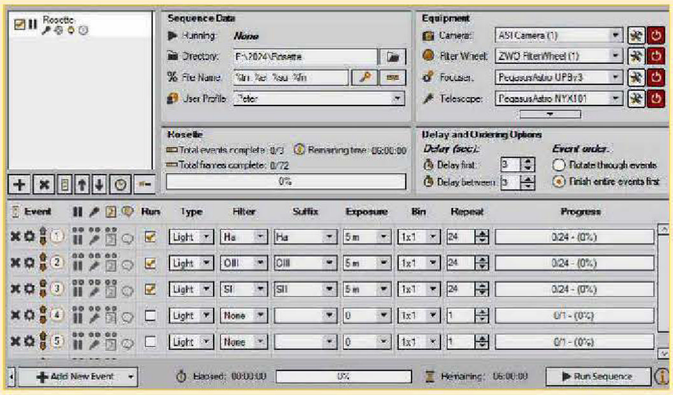
Step 1

Complete the 'Equipment' and 'User' profiles under SGPro's 'Tools' menu. The User profile is for details of your imaging site and the Equipment option has individual tabs for details of each item of equipment being used. Save both profiles for future use.



Step 2

Use the 'Framing & Mosaic Wizard' to choose a target, then add your image scale and sensor size. It's worth checking before using the wizard that your intended target is in your field of view. For this, the free software Stellarium is ideal.



Sequence Data
Running: None
Directory: F:\2024\Rosette
File Name: %tn_%el_%su_%fn
User Profile: Peter

Equipment
Camera: ASI Camera (1)
Filter Wheel: ZWO FilterWheel (1)
Focuser: PegasusAstro UPBv3
Telescope: PegasusAstro NYX101

Rosette
Total events complete: 0/3
Remaining time: 06:00:00
Total frames complete: 0/72

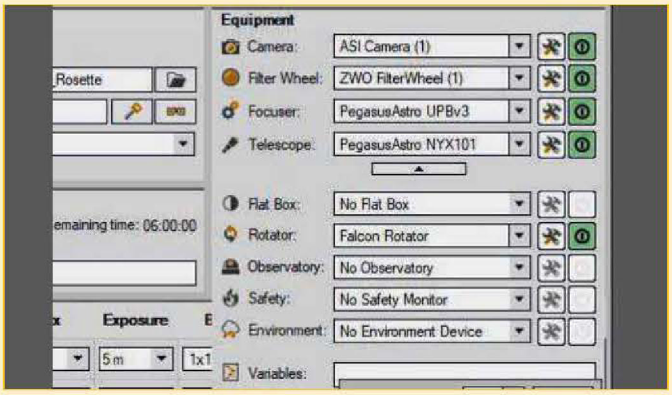
Delay and Ordering Options
Delay first: 3
Delay between: 3
○ Rotate through events
● Finish entire events first

Event	Run	Type	Filter	Suffix	Exposure	Bin	Repeat	Progress
1	☑	Light	Ha	Ha	5 m	1x1	24	0/24 - (0%)
2	☑	Light	OIII	OIII	5 m	1x1	24	0/24 - (0%)
3	☑	Light	SII	SII	5 m	1x1	24	0/24 - (0%)
4	☐	Light	None		0	1x1	1	0/1 - (0%)
5	☐	Light	None		0	1x1	1	0/1 - (0%)

Elapsed: 00:00:00 0% Remaining: 06:00:00

Step 3

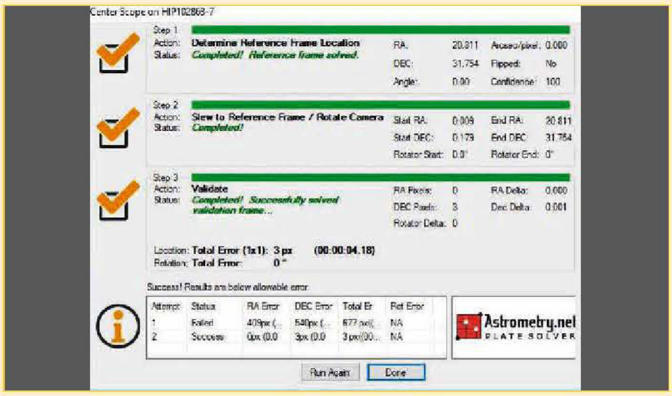
Fill in the details of the subframes you'd like in the 'Sequencer' menu, including the exposure time and number of exposures. If you're using filters, repeat the entries for each. Finally, in the Directory section specify where to save your images.



Equipment
Camera: ASI Camera (1)
Filter Wheel: ZWO FilterWheel (1)
Focuser: PegasusAstro UPBv3
Telescope: PegasusAstro NYX101
Flat Box: No Flat Box
Rotator: Falcon Rotator
Observatory: No Observatory
Safety: No Safety Monitor
Environment: No Environment Device
Variables:

Step 4

It's now time to connect your equipment. Tick the red buttons beside each in the top-right. Once connected, these turn green. If using a cooled camera, SGPro will cool it on connection. Once ready, unpark your mount and start your guiding software.



Center Scope on HIP102868-7

Step 1
Action: Determine Reference Frame Location
Status: Completed! Reference frame solved.
RA: 20.811 Arcsec/pixel: 0.000
DEC: 31.754 Flipped: No
Angle: 0.00 Confidence: 100

Step 2
Action: Slew to Reference Frame / Rotate Camera
Status: Completed!
Start RA: 0.009 End RA: 20.811
Start DEC: 0.179 End DEC: 31.754
Rotator Start: 0.0° Rotator End: 0°

Step 3
Action: Validate
Status: Completed! Successfully solved validation frame...
RA Pixels: 0 RA Delta: 0.000
DEC Pixels: 3 Dec Delta: 0.001
Rotator Delta: 0

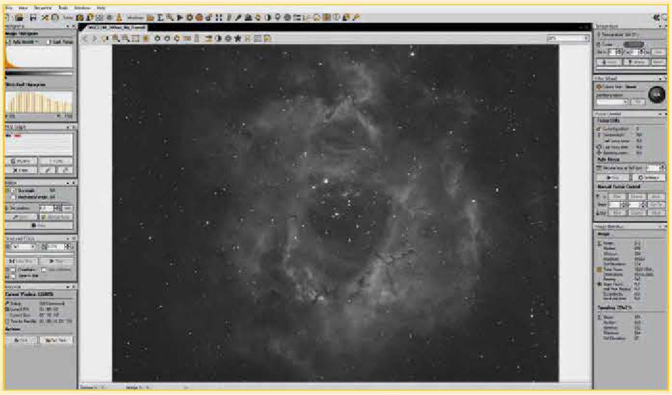
Location: Total Error (1x1): 3 px (00:00:04.18)
Rotation: Total Error: 0°

Success! Results are below allowable error

Attempt	Status	RA Error	DEC Error	Total Er	Rot Error
1	Failed	409px (...	540px (...	677 px((	NA
2	Success	0px (0.0	3px (0.0	3 px((00...	NA

Step 5

Click 'Run Sequence' in the Sequencer. SGPro will slew the mount to your target and start plate solving to check its position, readjusting as necessary. Once successfully located, SGPro will restart your guiding software and will be ready to image.



Step 6

Each frame you capture appears on screen temporarily stretched so that they can be rejected if necessary (due to a satellite crossing, for example). If you reject an image, SGPro offers to increase the number of exposures to compensate.

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

Experiments with Venus's light

Try these interesting projects that play with the brilliant light of the Evening Star

▲ **The blazing glory that is Venus in a dark sky is a chance to do some simple and fascinating experiments with its light**

Venus is prominent in the evening sky after sunset, a veritable beacon due to its mag. –4.5 brilliance. It's so bright that tales describe how the planet has been mistaken by pilots for an oncoming plane. With it so well placed in the early evening sky this month, we have a great opportunity to use the planet for some less-than-conventional imaging and interesting experiments.

Venus's impressive brightness comes from the fact that it's covered in reflective cloud. Albedo is the fraction of light reflected by a body, which for Earth is 0.43. For Venus it's 0.69 or nearly 70 per cent. Combined with its closer proximity to the Sun, it's no wonder it looks so brilliant in our evening or morning sky.

Without any magnification, Venus is effectively a point source of light and we can use this to create some interesting effects. In astronomy, the diffraction of light is a double-edged sword. For reflecting telescopes, the struts supporting the secondary mirror lower contrast and produce artefacts known as diffraction spikes. Some see these as an inevitable nuisance of the design. A refractor or any other design without secondary supports won't produce diffraction spikes, but those with significant secondary mirrors still suffer a loss of contrast due to diffraction at the edge of the secondary assembly.

Whether you like them or hate them, natural diffraction spikes (as opposed to the artificial ones some imagers add using software) can be quite amazing, and the crown for the best object that produces them must go to Venus. If you're using a reflector, you'll get the spikes by default, but if you have a refractor, you can experience them by placing a taught piece of cotton thread across the front of the scope. Each cotton line produces two spikes each at right angles to the cotton's length. A cross pattern emulates the diffraction spikes of a typical reflector, but other patterns can be created too.

When Venus is sufficiently separated from the Sun and in an optimum position to retain a decent altitude when true darkness falls, in the absence of any other light sources, such as the Moon, you may be able to see and record the shadow caused by its light. Shadows cast by Venus are remarkable because they have very sharp edges.

If you have a relatively flat horizon, the brilliance of Venus also allows you to follow the planet to a lower altitude than would be possible with dimmer objects. This can reveal something remarkable about Earth's atmosphere, as Venus at low altitude shows the effects of both wobbly seeing and atmospheric dispersion very well. Atmospheric dispersion is an effect where the atmosphere acts like a prism, spreading an object's light into a spectrum of colour.

Of course, there are plenty of regular ways to observe and image Venus too, but it's great to take advantage of it being in such a prominent and optimal position during February.

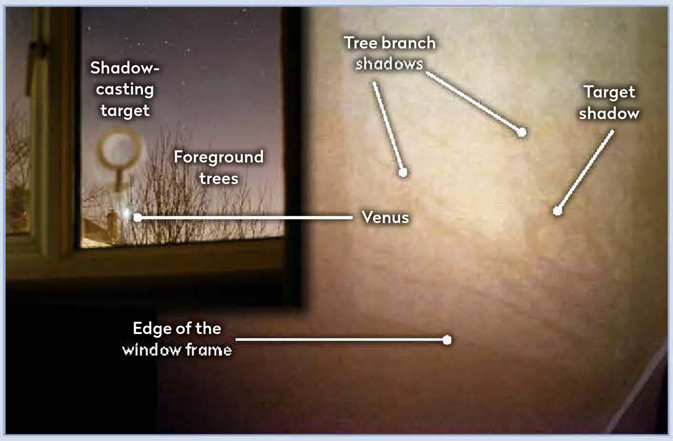
Pete Lawrence is an expert astro-imager and a presenter on *The Sky at Night*

Equipment: Cardboard, box enclosure, cotton thread, camera, telephoto lens or refracting telescope

✉ **Send your images to:**
gallery@skyatnightmagazine.com

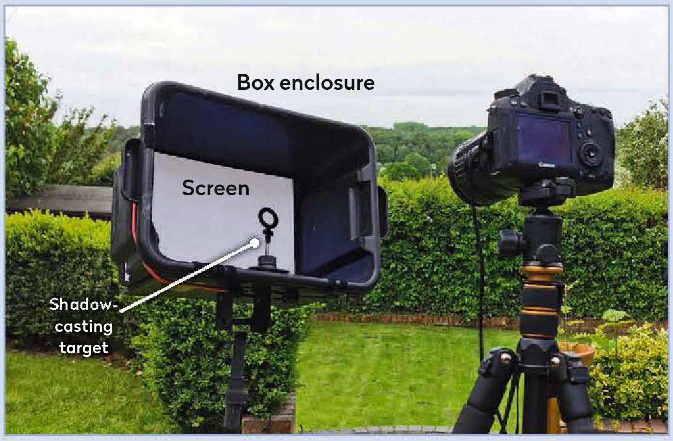
ALL PICTURES: PETE LAWRENCE

Step by step


Shadow-casting target
Tree branch shadows
Target shadow
Foreground trees
Venus
Edge of the window frame

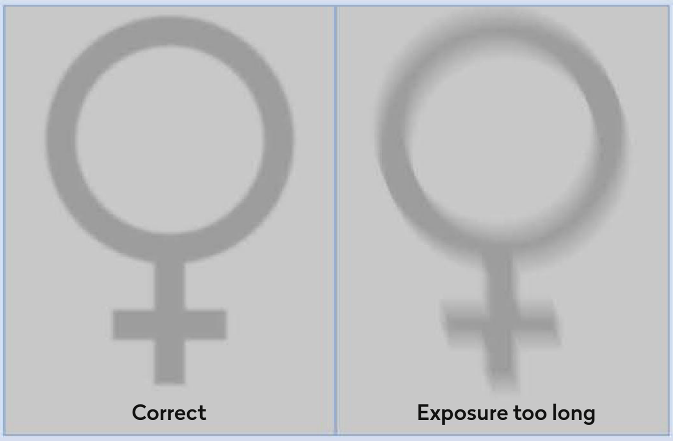
STEP 1

To capture the shadow cast by Venus, you'll need a flat western horizon free from significant light sources. The Moon is out of the way after the middle of February, making that the perfect time to try. A room with a window facing west is ideal, but if this isn't viable, a large cardboard box or equivalent can be used.


Box enclosure
Screen
Shadow-casting target

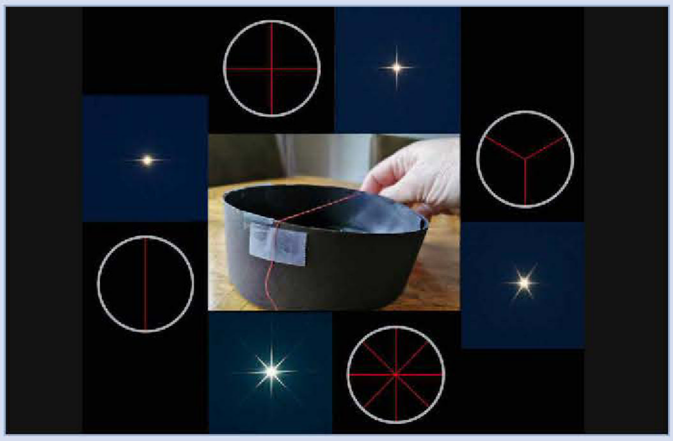
STEP 2

Attach sheets of white paper to the bottom of your box to create a screen. The shadow-casting target should be placed in the open side of the box. Wait until true darkness falls, then point the open end of the box at Venus. Using a camera, try to record the shadow of the target on the screen surface.


Correct
Exposure too long

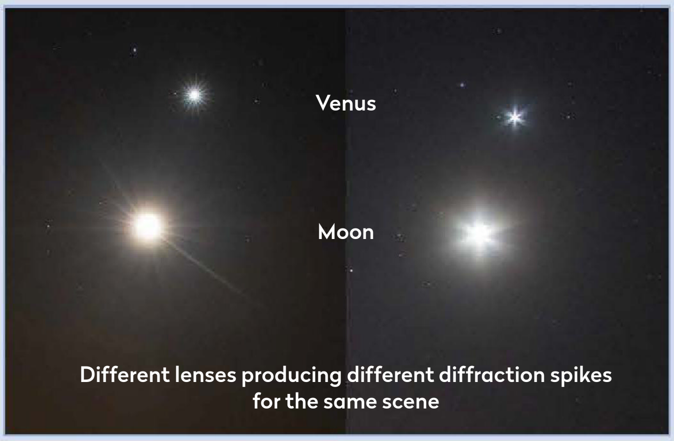
STEP 3

Ideally, use a reasonably high ISO and low f/ number to keep exposure times short. Too long and the shadow will blur due to the apparent movement of the sky. Before you take your shot, use a torch to cast the target's shadow on the screen, then focus the camera lens as accurately as possible on the shadow's edge.



STEP 4

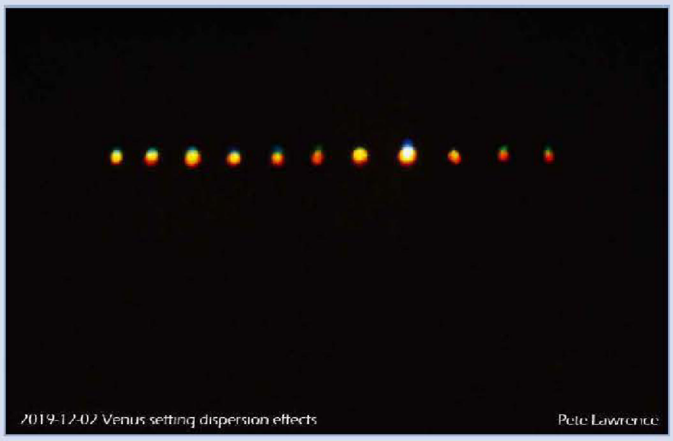
To make Venusian diffraction spikes, fit a cardboard collar over the front aperture of a telescope or camera lens. Attach two lengths of cotton thread in a cross pattern to the collar. Aim at Venus, focus and take a shot. Different arrangements of cotton will make different diffraction patterns, so experiment away.



Different lenses producing different diffraction spikes for the same scene

STEP 5

An alternative way to produce dramatic diffraction effects is to stop the lens aperture down. Setting the lens f/ number to f/11–f/16 will cause the aperture blades to close, the edge of each one creating a diffraction spike. The effect does vary between lenses, but it can look very dramatic.


2019-12-02 Venus setting dispersion effects
Pete Lawrence

STEP 6

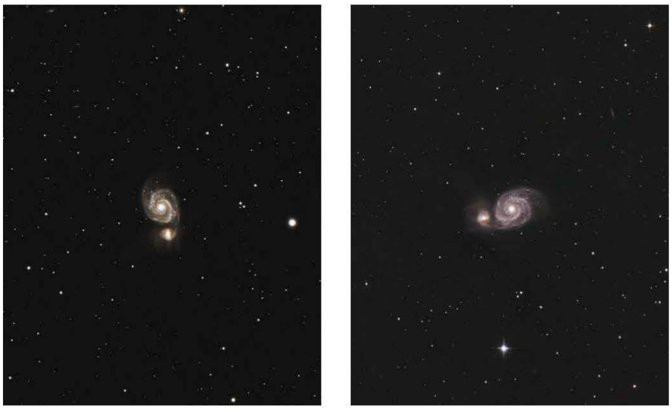
If you're able to follow Venus using a telescope as it gets very close to the horizon, you may see its light smear into a spectrum of colour due to atmospheric dispersion. Take regular exposures a second or so apart and you'll see this spectrum flickering like a flame as atmospheric seeing introduces the wobbles.

Expert processing tips to enhance your astrophotos

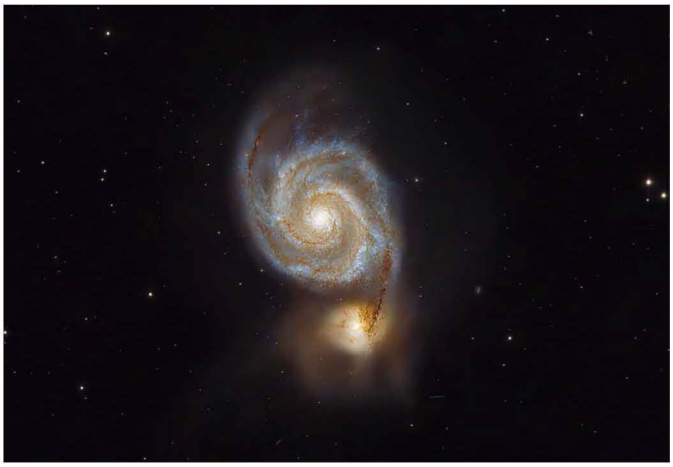
ASTROPHOTOGRAPHY PROCESSING

How to blend images taken with different camera setups

Combine data captured at varied focal lengths to create rich, deep images



▲ **Jim's original shots of the Whirlpool Galaxy, captured using (left) a William Optics GT81 with a focal length of 382mm, paired with an Altair 183c camera, 52x 180" and (right) an Altair Newtonian with a focal length of 770mm, paired with an Altair 26C camera, 116x 120"**



▲ **His beautiful final image, after using Astro Pixel Processor (APP) to combine the two datasets before then cropping and processing**

Astrophotographers often return to the same targets to rephotograph them using different equipment. As a result, we often end up with multiple sets of frames captured with a range of focal lengths or camera sensors. Combining this data can produce stunning images that can be cropped in tightly to reveal intricate features.

One program that does this well is Astro Pixel Processor (APP), a powerful tool that easily blends multi-focal-length data in a few simple steps. Here I'll explain how to use APP to produce a high-resolution image, using my Whirlpool Galaxy image (above), made using data from two different imaging setups, including a triplet refractor and a Newtonian reflector.

Before opening APP, I went through each dataset of images and removed any frames containing plane trails, clouds or other unwanted elements. I also took dark and flat calibration images for each and saved the datasets into two folders.

When you first open APP, a window pops up asking you to select a working directory, the location where you have saved your data. If for any reason this does not pop up, click the 'Directory' button (highlighted, Screenshot 1) and navigate to your image folders.

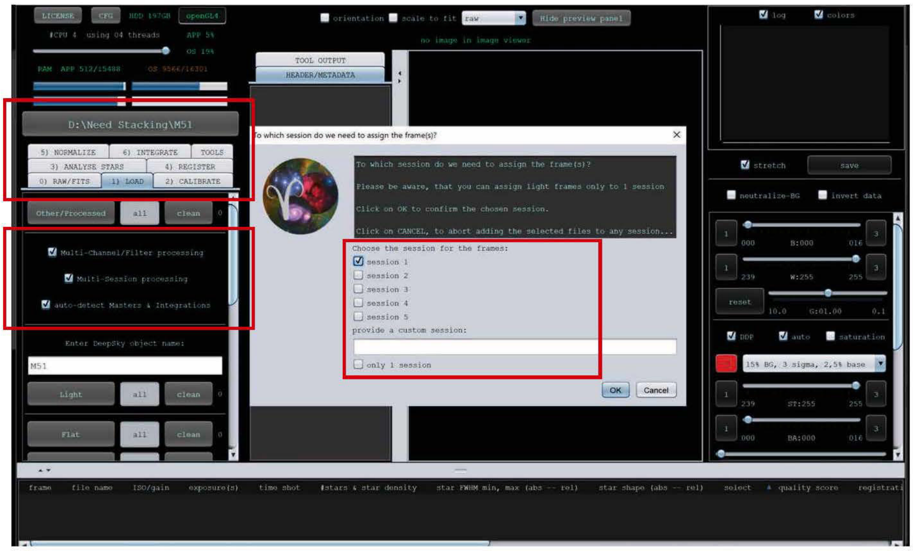
Beneath the working directory button is a series of tabs numbered 0) to 6), which will prepare your datasets for stacking. The '1) Load' tab is where to load your light frames and calibration frames. First, ensure the three tick boxes are selected. Next, click the 'Light' button underneath and navigate to the folder that contains the light frames from your first dataset, select all and click 'Ok'. A pop-up will ask what channel your light frames should be assigned to. As mine were colour images, I selected 'RGB'.

Create your masters

Another pop-up will appear, asking what session to assign the files to. As these are the light frames from your first dataset, tick 'session 1' (see Screenshot 1). Next, upload any calibration frames for dataset 1 by selecting the 'Flat' and 'Dark' buttons and repeating the above steps for the calibration files. Repeat this step for the light and calibration frames from dataset 2; this time select the 'session 2' option.

Clicking on the '2) Calibration' tab, leave all settings as default. If you're using master calibration frames, click on '(Re-) assign Masters to Lights'. If not, click 'create Masters & assign to Lights'. Next, head to '3) Analyse stars'. This is where

ALL PICTURES: JIM OWEN


D:\Need Stacking\M51

☑ Multi-Channel/Filter processing

☑ Multi-Session processing

☑ auto-detect Masters & Integrations

Enter DeepSky object name: M51

To which session do we need to assign the frame(s)?

To which session do we need to assign the frame(s)?

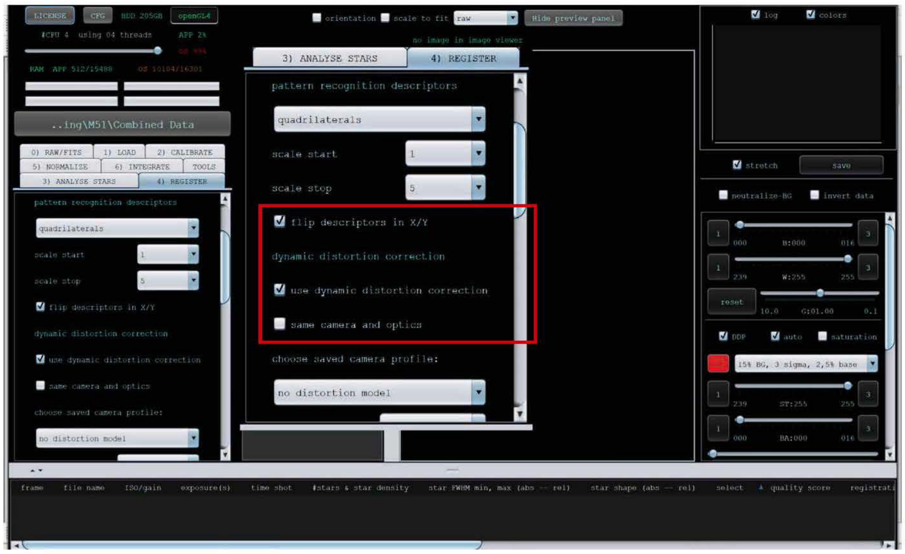
Please be aware, that you can assign light frames only to 1 session

Click on OK to confirm the chosen session.

Click on CANCEL, to abort adding the selected files to any session...

Choose the session for the frames:
☑ session 1
☐ session 2
☐ session 3
☐ session 4
☐ session 5
provide a custom session:
☐ only 1 session

▲ Screenshot 1: click the three tick boxes shown before loading your light and calibration frames. Assign these to 'session 1'. Repeat for your second dataset and save as 'session 2'


..ing\M51\Combined Data

3) ANALYSE STARS | 4) REGISTER

pattern recognition descriptors: quadrilaterals

scale start: 1

scale stop: 5

☑ flip descriptors in X/Y

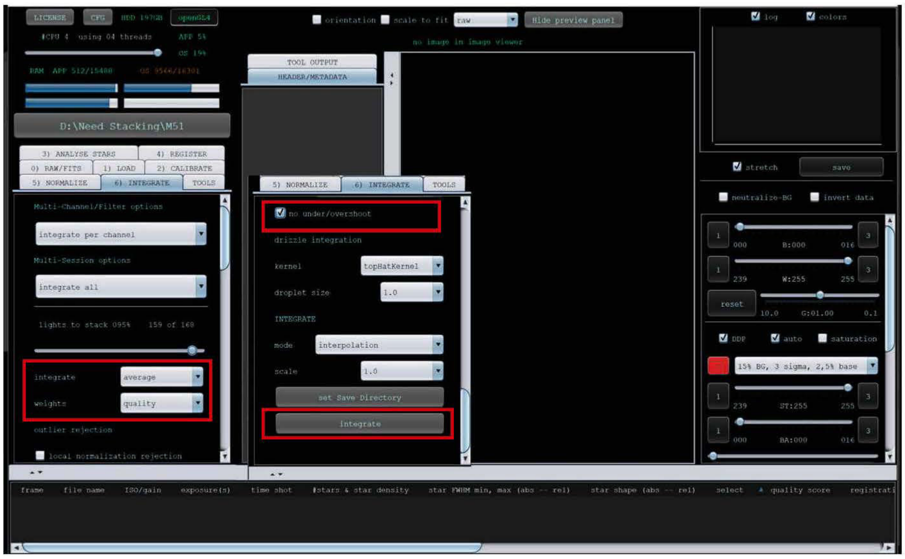
dynamic distortion correction

☑ use dynamic distortion correction

☐ same camera and optics

choose saved camera profile: no distortion model

▲ Screenshot 2: click '4) Register', tick 'flip descriptors in X/Y' and 'use dynamic distortion correction' but untick 'same camera and optics'. Click 'start registration'


D:\Need Stacking\M51

Multi-Channel/Filter options: integrate per channel

Multi-Session options: integrate all

lights to stack 095% 159 of 168

integrate: average

weights: quality

outlier rejection

☐ local normalization rejection

☑ no under/overshoot

drizzle integration

kernel: topHatKernel

droplet size: 1.0

INTEGRATE

mode: interpolation

scale: 1.0

▲ Screenshot 3: initially set the '6) Integrate' options as we outline; you can experiment later. Click 'integrate', name your image and click 'ok' to start stacking. When finished, save your final image for cropping and other adjustments in your preferred processing program

3 QUICK TIPS

1. Organise your light and calibration files into separate folders for each dataset.

2. 'Pre-calibrate' your light frames in APP beforehand to speed up the stacking process.

3. Experiment with different settings in the 'Integrate' tab to see how they impact your stacked image.

APP will review each light frame for its star quality. Simply scroll down and click 'Analyse', then wait for the script to finish.

Next, click '4) Register'. The following steps enable the multiple datasets to register correctly (see Screenshot 2): tick 'flip descriptors in X/Y' and 'use dynamic distortion correction'. As this data is from different camera and telescope setups, be sure to untick the toggle box for 'same camera and optics' before clicking 'start registration'.

On the '5) Normalize' tab, access the advanced normalisation function by selecting 'advanced' from the dropdown menu. Leave all other options as default, click 'normalize lights' and wait to process.

Our last stop is '6) Integrate' (see Screenshot 3). We suggest adjusting the slider to 95 per cent, so that APP picks the best 95 per cent of the light frames for stacking. Other things to change in this tab include setting integrate to 'average', weights to 'quality', composition to 'full' and LNC to 'no LNC'. Ensure MBB is ticked; typically you want to set this at 5–15 per cent; 5 per cent is generally fine. Tick 'No under/over shoot' and, finally, click 'integrate'. A window will pop up, allowing you to give the stacked image a name, after which click 'Ok'. Note, the stacking process takes a while!

Once complete, save your stacked image in your working directory, ready to crop out any remaining stacking artefacts and continue editing. My final image of the Whirlpool Galaxy (opposite, right) shows how far I could crop and how many additional details could be teased from my multi-setup image.

Jim Owen is a UK astrophotographer with a passion for capturing galaxies and faint nebulae in stunning detail

Your best photos submitted to the magazine this month

ASTROPHOTOGRAPHY GALLERY

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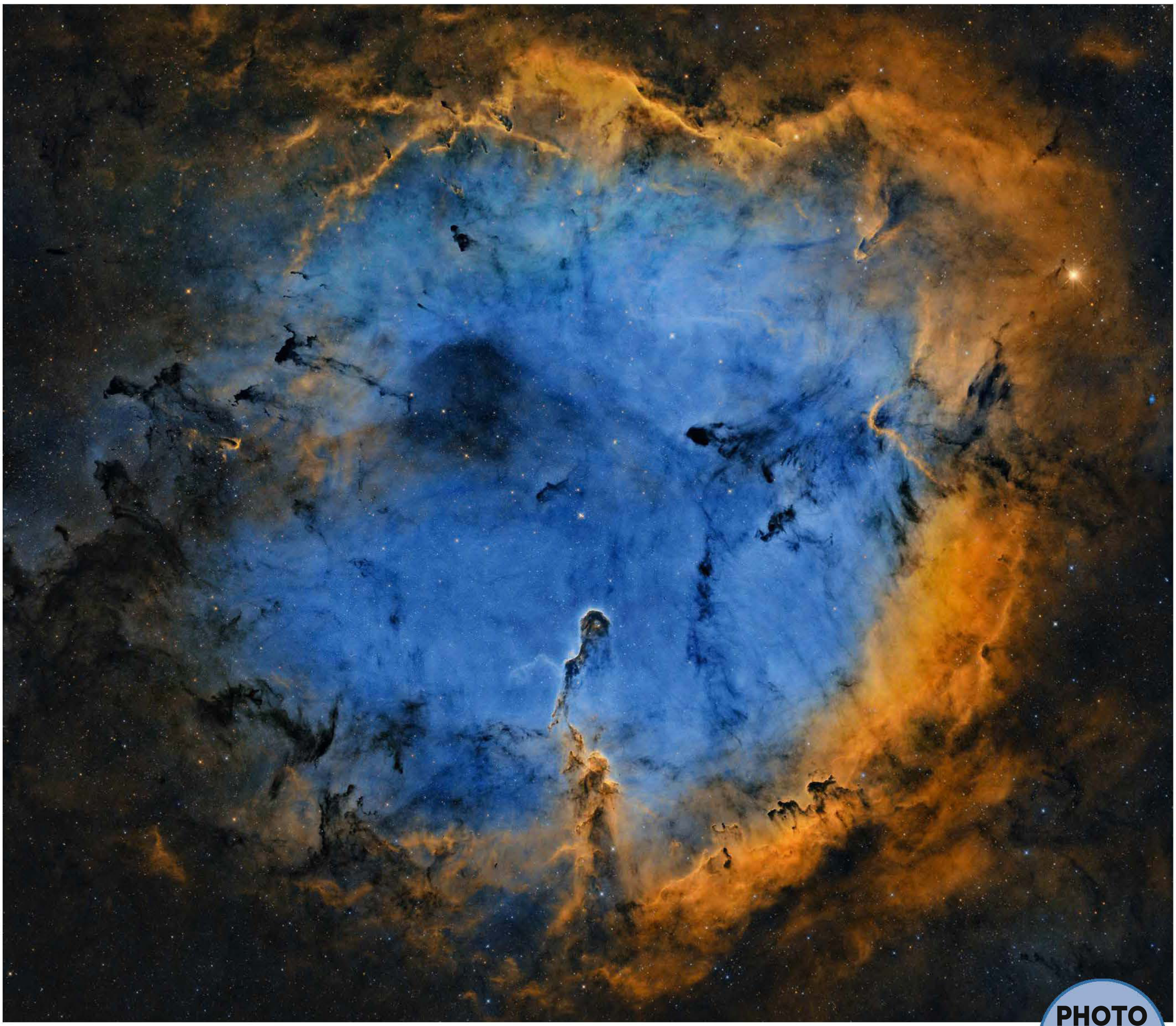


PHOTO OF THE MONTH

△ The Elephant's Trunk Nebula

Simon Todd, Haywards Heath, West Sussex, September 2023–October 2024

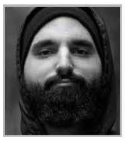
Simon says: "This two-panel image is part of a larger eight-panel mosaic. Capturing it was challenging due to the unpredictable British weather, but I'm pleased with how it turned out."

Equipment: ZWO ASI2600MM Pro camera, SharpStar 20032PNT reflector, Sky-Watcher EQ8 Pro mount
Exposure: Ha 146x 300", OIII 201x 300", SII 151x 300", 41h 50' total
Software: Astro Pixel Processor, PixInsight

Simon's top tips: "It's about patience. Light has travelled for millions of years to reach your telescope, so there's no need to rush! Keep at it and the results will come. And use calibration frames – they're essential for turning your data into stunning images."

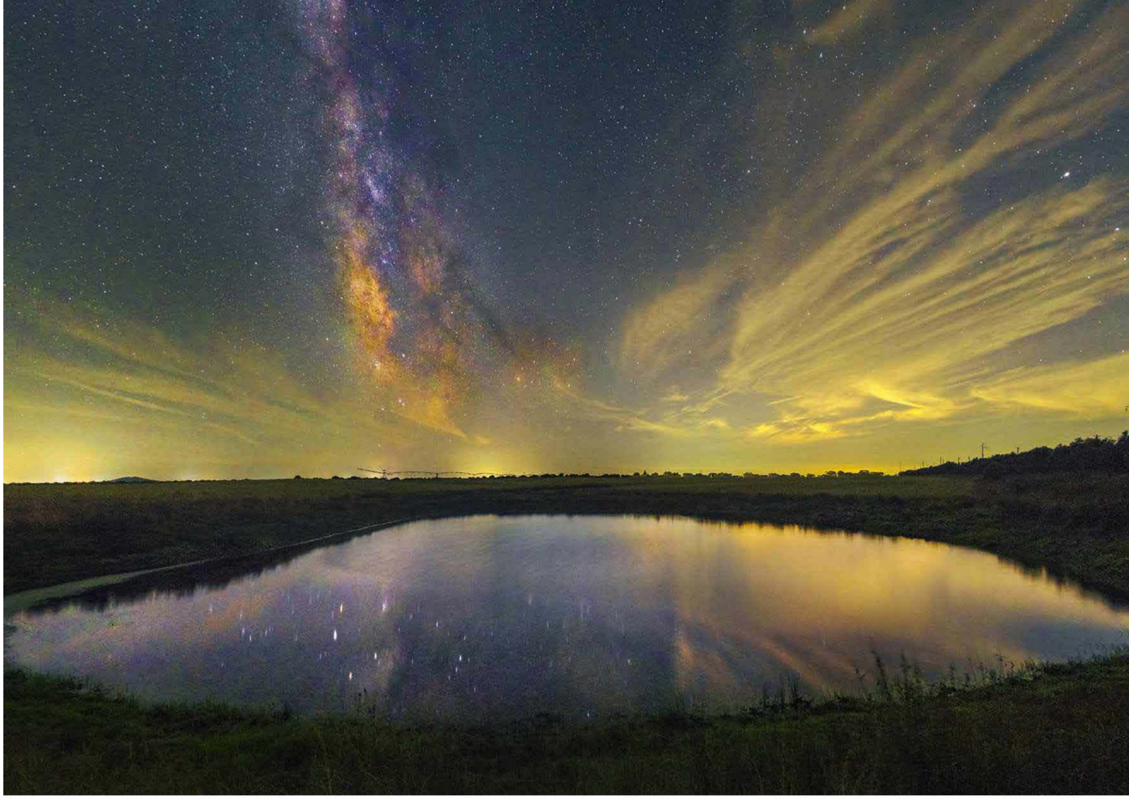
The Milky Way ▷

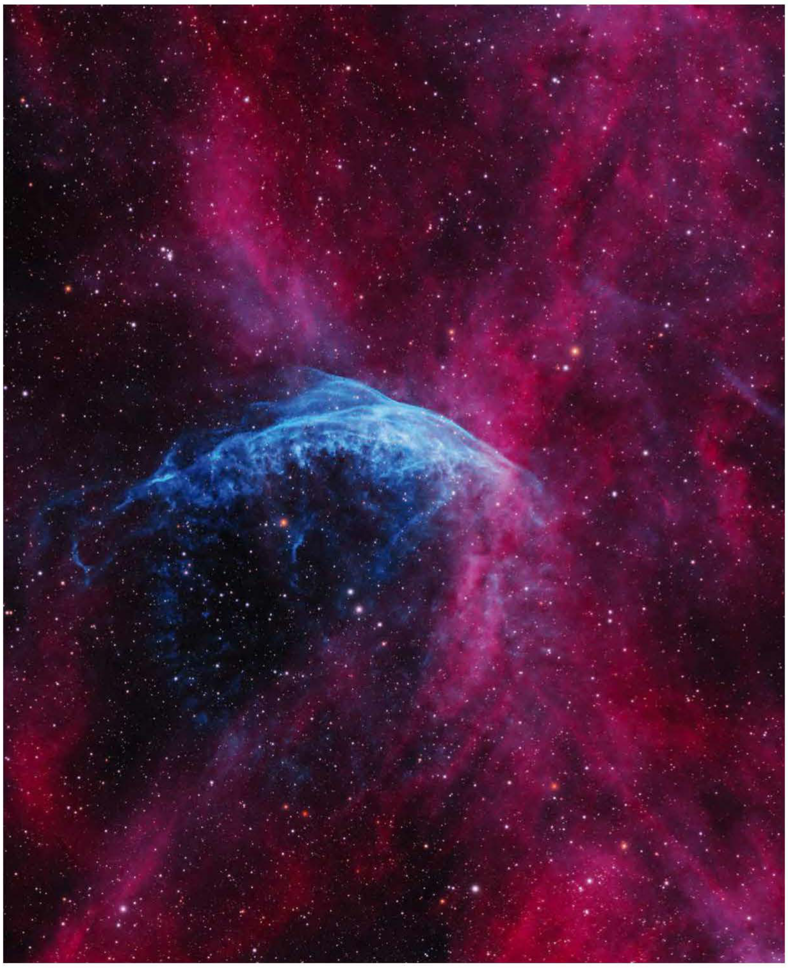
Rui Santos, Pavia, Alentejo, Portugal, 26 August 2024



Rui says: "I faced numerous challenges capturing this shot. Dense vegetation and eerie animal sounds made it a surreal experience, but I persevered and finally completed the panorama."

Equipment: Sony A6000 camera, Samyang 12mm lens, Geekoto AT24 Pro Dreamer tripod
Exposure: ISO 6400 f/2.8, 16x 20"
Software: Lightroom, Photoshop, Image Composite Editor, Luminar





△ Wolf-Rayet star WR 134

Steve Leonard, Markham, Ontario, Canada, May–June 2024

Steve says: "WR 134 is a variable Wolf–Rayet star about 6,000 lightyears from Earth. During processing, I noticed the remarkable 'X' pattern of the hydrogen gas and decided to frame the image centred on this glowing X."

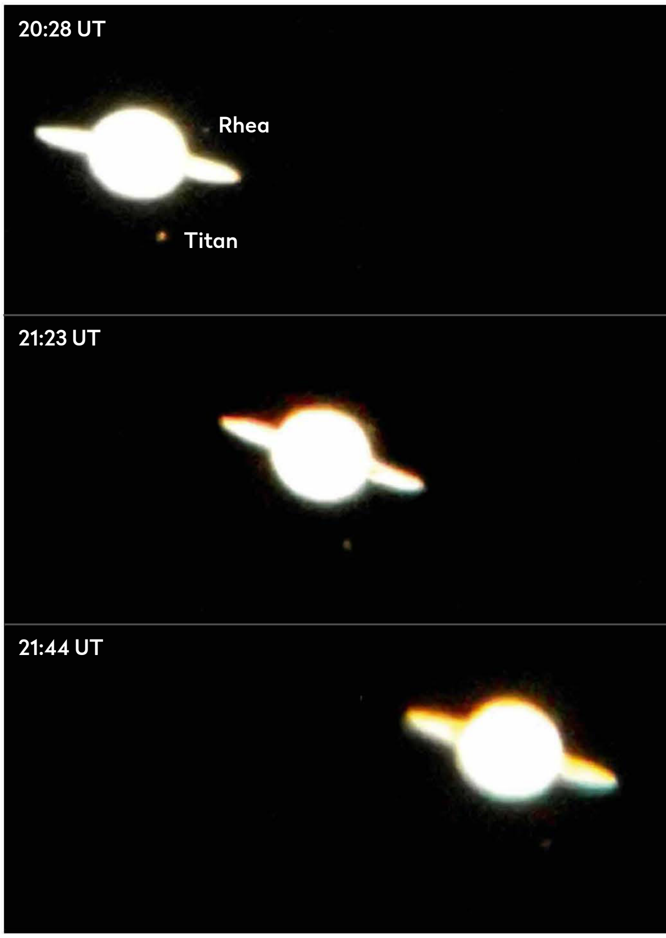
Equipment: ZWO ASI1600MM Pro camera, Astro-Tech AT115EDT refractor, Sky-Watcher EQ6-R mount
Exposure: OIII 10h, Ha 10h, RGB 1.5h **Software:** PixInsight, Topaz DeNoise

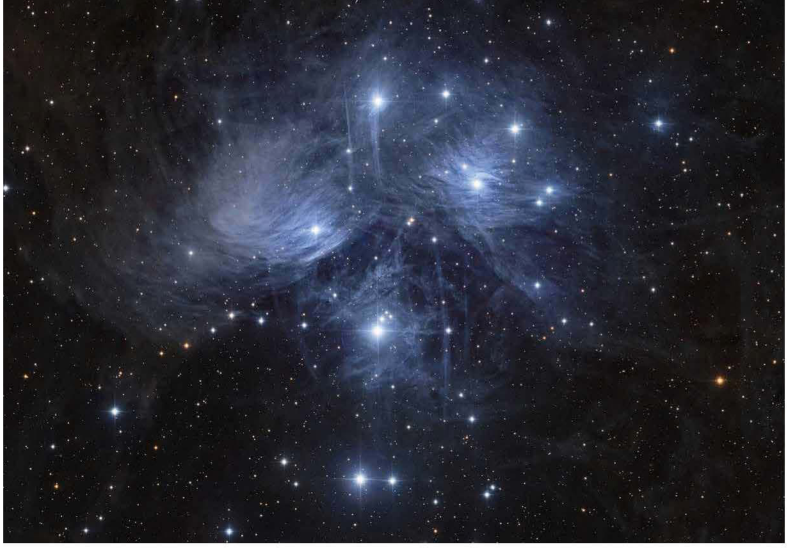
▽ Partial eclipse of Titan

Paolo Palma, Rome, Italy, 27 October 2024

Paolo says: "Stellarium had promised me a full eclipse, but on the night I actually only witnessed a partial one. Titan was still visible but less bright, and I captured these three frames."

Equipment: Huawei P30 smartphone, Meade LightBridge 12-inch Dobsonian
Exposure: ISO 5000, 1/15" **Software:** GIMP





△ The Pleiades

Warren Keller and Kenny Lewis, Weeki Wachee, Florida, USA, 1 December 2021

Warren says: "I created this image from data captured by Kenny in 2021, after Kenny and I met by chance. I was 900 miles from home and walking my dog, when I spotted his imaging rig over a hedge!"

Equipment: ZWO ASI2600MC Pro camera, Celestron Edge HD 11-inch Schmidt–Cassegrain, iOptron CEM120 mount **Exposure:** 42x 300" **Software:** PixInsight, Photoshop

▽ Reflection nebulae IC 59 and IC 63

David Hugill, Cirencester, Gloucestershire, 11 November 2024

David says: "This was a challenge to capture due to the faintness of the nebulae and the close proximity of the bright star Gamma Cassiopeiae, but I'm pleased with the end result."

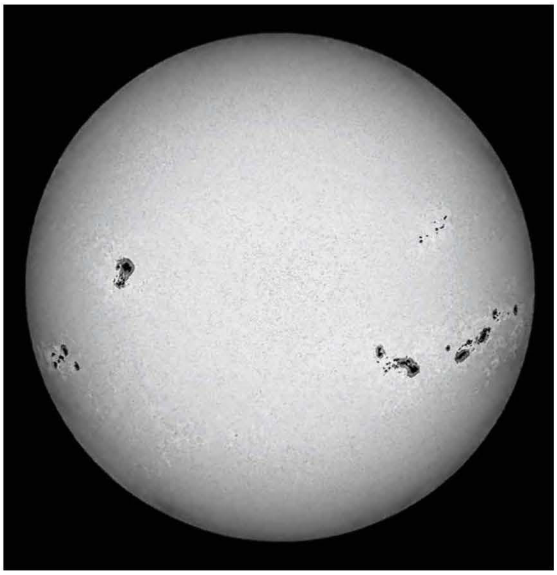
Equipment: ZWO ASI585MC Pro camera, StellaMira 90mm refractor, ZWO AM3 mount **Exposure:** 104x 300" **Software:** PixInsight

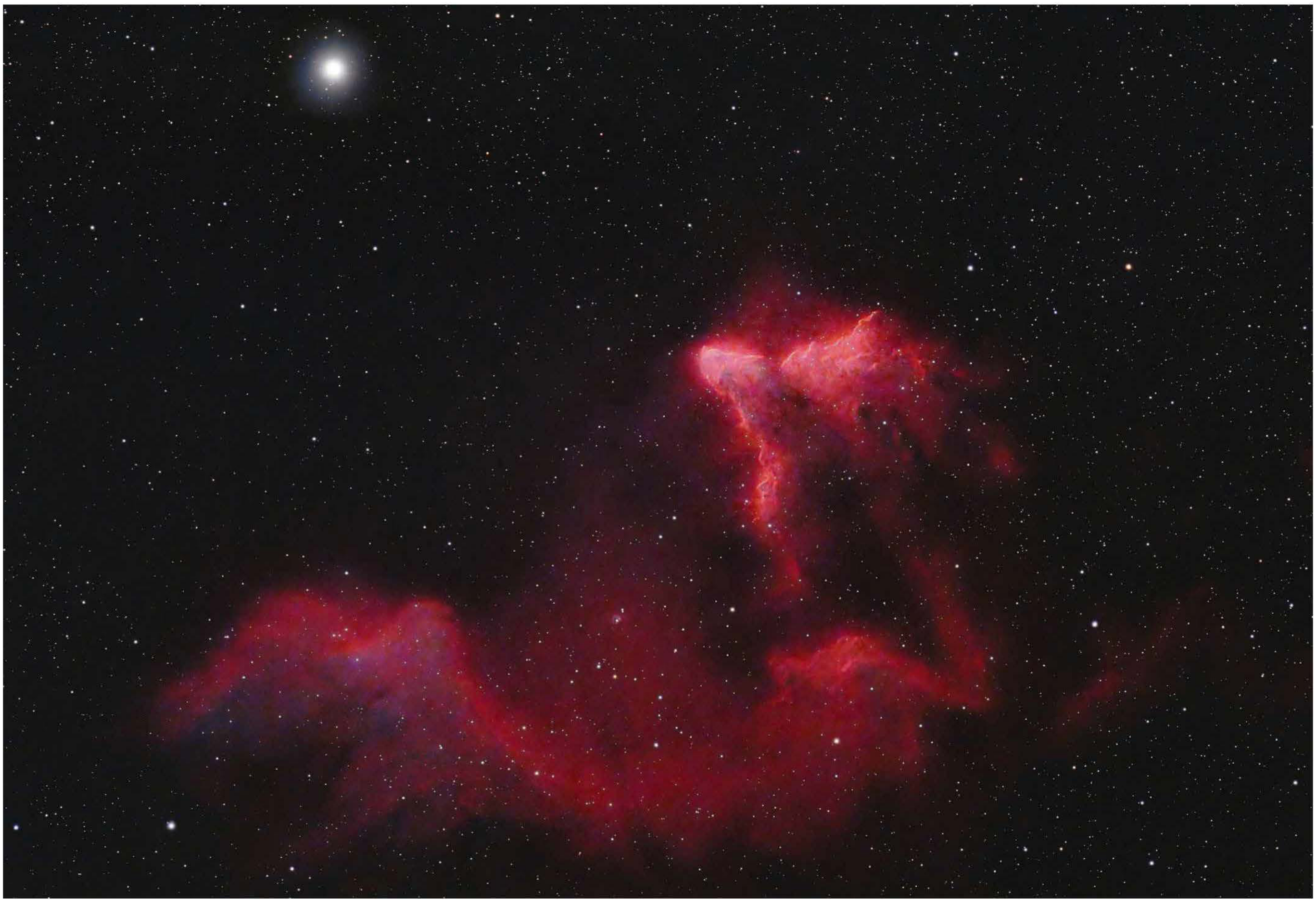
▽ The Sun

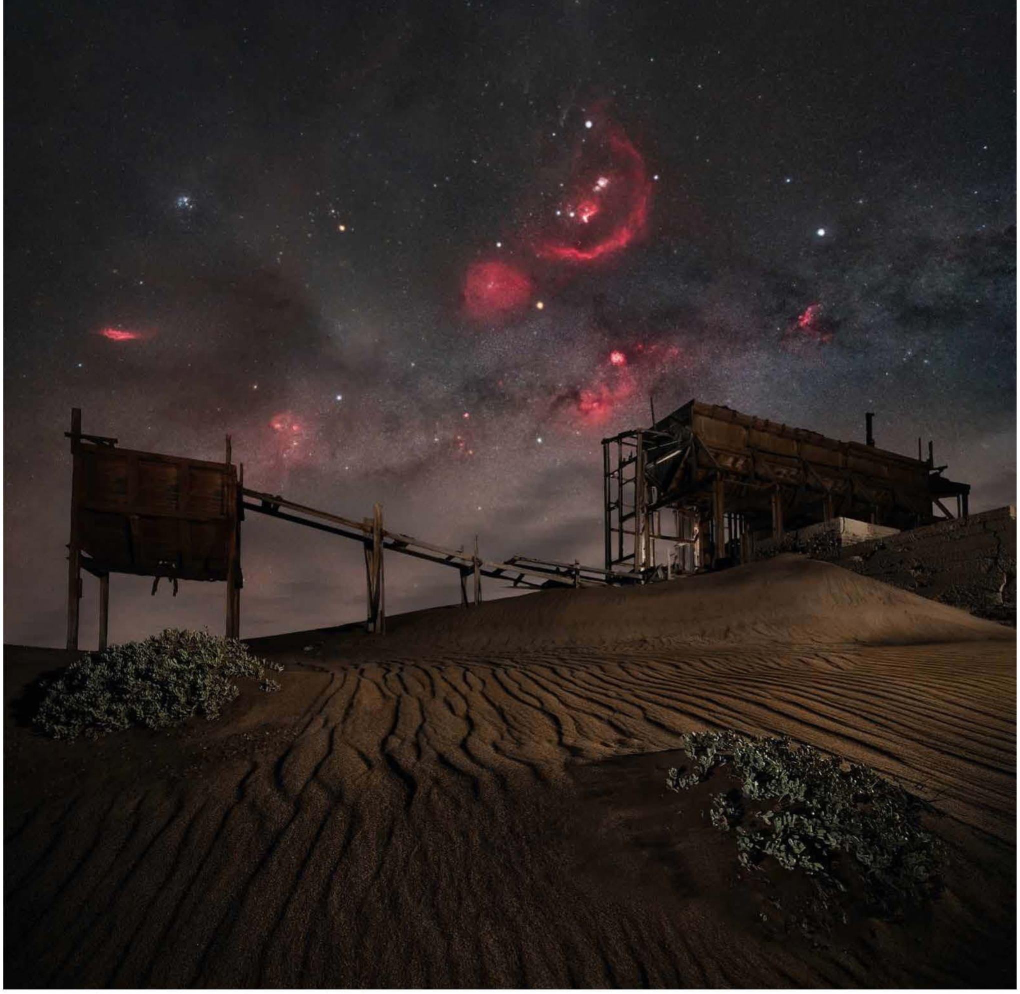
Sonia Turkington, North Reddish, Cheshire, 5 October 2024

Sonia says: "The Sun has been very active lately and I've enjoyed capturing some great images using the Seestar S50 and a Baader solar filter."

Equipment: Seestar S50 smart telescope **Exposure:** 10" **Software:** GridArt







◁ Night sky over Bogenfels

Vikas Chander, Bogenfels, Namibia, 24 September 2024

Vikas says: "Namibia's dark skies are great for astrophotography! In this shot in the 'ghost' mining town of Bogenfels you can see the Pleiades, the Taurus asterism and at least seven well-known nebulae."

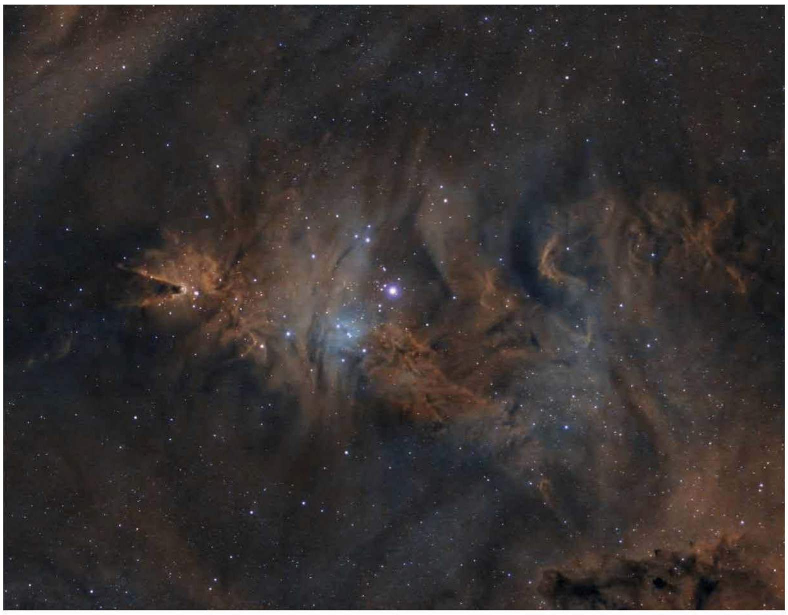
Equipment: Sony a7R V camera, Sony 12–24mm lens, Really Right Stuff TVC-45 mount
Exposure: Sky ISO 800 f/2.8, 12x 300"; foreground ISO 800 f/2.8, 480"
Software: PixInsight, Photoshop

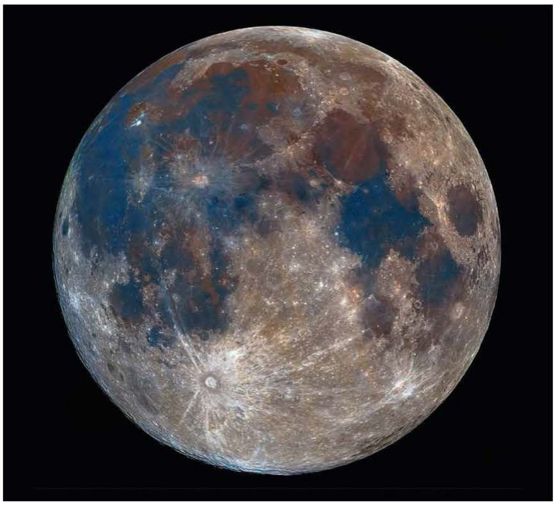
▽ The Christmas Tree Cluster

Martin Bracken, Chelmsford, Essex, 21 November 2024

Martin says: "This image of NGC 2264 shows the area of dark nebulosity surrounding the cluster. The stars have been reduced to highlight the detail in the nebulosity."

Equipment: ZWO ASI294MC Pro camera, Spy-Watcher Esprit 100ED refractor, Sky-Watcher EQ6-R Pro mount **Exposure:** 25x 300"
Software: Astro Pixel Processor, PixInsight, Affinity Photo





△ Beaver Moon

Karthik Easvur, Delhi, India, 15 November 2024

Karthik says: "To photograph the last supermoon of 2024 in high resolution, I captured 24 images of different regions of the Moon and used them to create this mosaic."

Equipment: ZWO ASI662MC camera, GSO 6-inch Ritchey–Chrétien, Explore Scientific EXOS-2 PMC-Eight mount
Exposure: 24x 30" videos, stacked
Software: AutoStakkert!, RegiStax, PixInsight, Photoshop

ENTER YOUR IMAGE

Whether you're a seasoned astrophotographer or a beginner just starting out, we'd love to see your images. Send them to us at www.skyatnightmagazine.com/send-us-your-astrophotos

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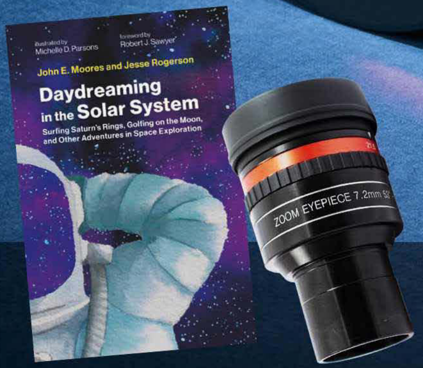
86

Has the reliably innovative ZWO brand done it again with its 3-in-1 smart camera? Read on to find out what our reviewer thought

ZWO
ASI 2600MC Air


Illustrated by Michelle D. Parsons
Foreword by Robert J. Sawyer
John E. Moores and Jesse Rogerson
Daydreaming in the Solar System
Surfing Saturn's Rings, Golfing on the Moon, and Other Adventures in Space Exploration
ZOOM EYEPIECE 7.2mm

PLUS: top gadget picks and new books, including musings on visiting our neighbour planets and life on an Earth without stars

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HOW WE RATE

Each product we review is rated for performance in five categories.
Here's what the ratings mean:

★★★★★ Outstanding ★★★★★ Very good
★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid

Our experts review the latest kit

FIRST LIGHT

ZWO ASI2600MC Air colour wireless smart camera

Autoguiding, imaging and app control combine in one seamless package

WORDS: TIM JARDINE

VITAL STATS

- **Price** £2,149
- **Main sensor** Sony IMX571
- **Resolution** 6,248 x 4,176
- **Exposure range** 32ms–2,000s
- **Size** 98mm x 90mm, antenna 94mm
- **Compatibility** iOS, Android, Linux, ASCOM
- **Connectivity** USB 2.0
- **Weight** 760g
- **Supplier** 365 Astronomy
- **Tel** 020 33 845 187
- **www.**365astronomy.com

There's a growing trend in the astrophotography market for smart devices – Wi-Fi-connected equipment that simplifies the way we capture images of the night sky. ZWO's ASI2600MC Air is a wireless smart camera that aims to do just that by combining three elements in one compact unit: a main imaging camera, a guide camera and an astrophotography controller.

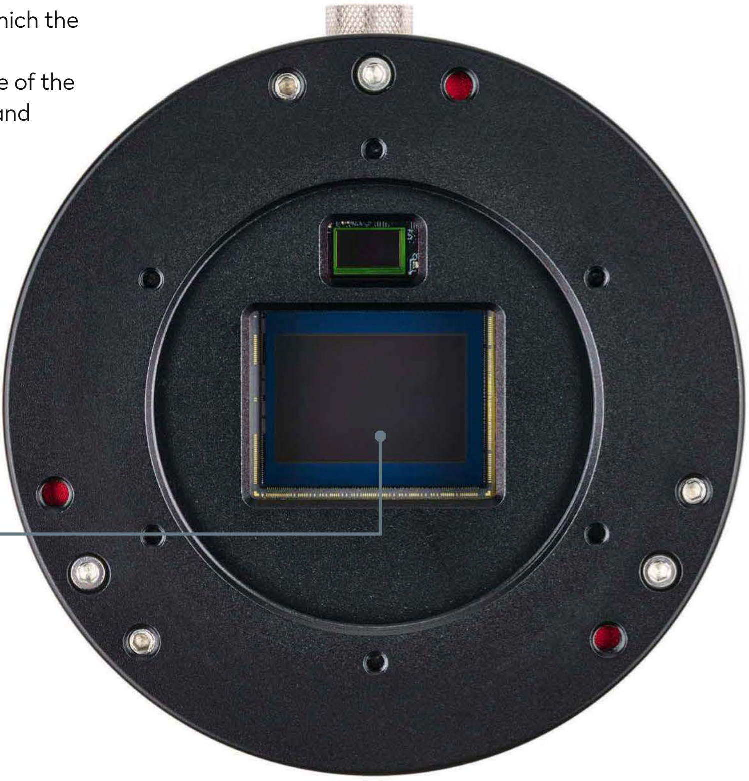
At first glance, the ASI2600MC Air looks like a standard deep-sky camera. It is barrel-shaped, mid-size and surprisingly lightweight at just 760g. However, a look at the front of it reveals that behind the M54 tilt plate there are *two* CMOS sensors: an APS-C-sized 26MP 'main capture' sensor and a smaller 1/1.8-inch high-sensitivity sensor above it. Another clue to the extra capability on offer is found at the rear of the body where there's a Wi-Fi antenna, which establishes a signal through which the ASI2600MC Air can be controlled.

Veteran astro imagers will be aware of the almost laughable amount of cables and connections often needed to control astrophotography setups. This camera completely side-steps that problem, as the only cables it requires are a 12V/3A–10A DC input to power it up, and if you don't have the newer, Wi-Fi- or Bluetooth-enabled kind of mount, then an appropriate cable to link the two together. We used a USB-to-serial lead on our older mount, which connected and worked seamlessly, allowing full control of our mount via the included ASiair app.

No spaghetti of cables

Because the guiding sensor uses the main telescope, there's no need for a separate guidescope. As a seasoned off-axis guide user, this dual-sensor arrangement proved to be far superior because there was almost nothing to set up. In fact, the initial set-up was so uncomplicated it made the rest of our observatory cameras, guide systems and cable harnesses appear rather old-school.

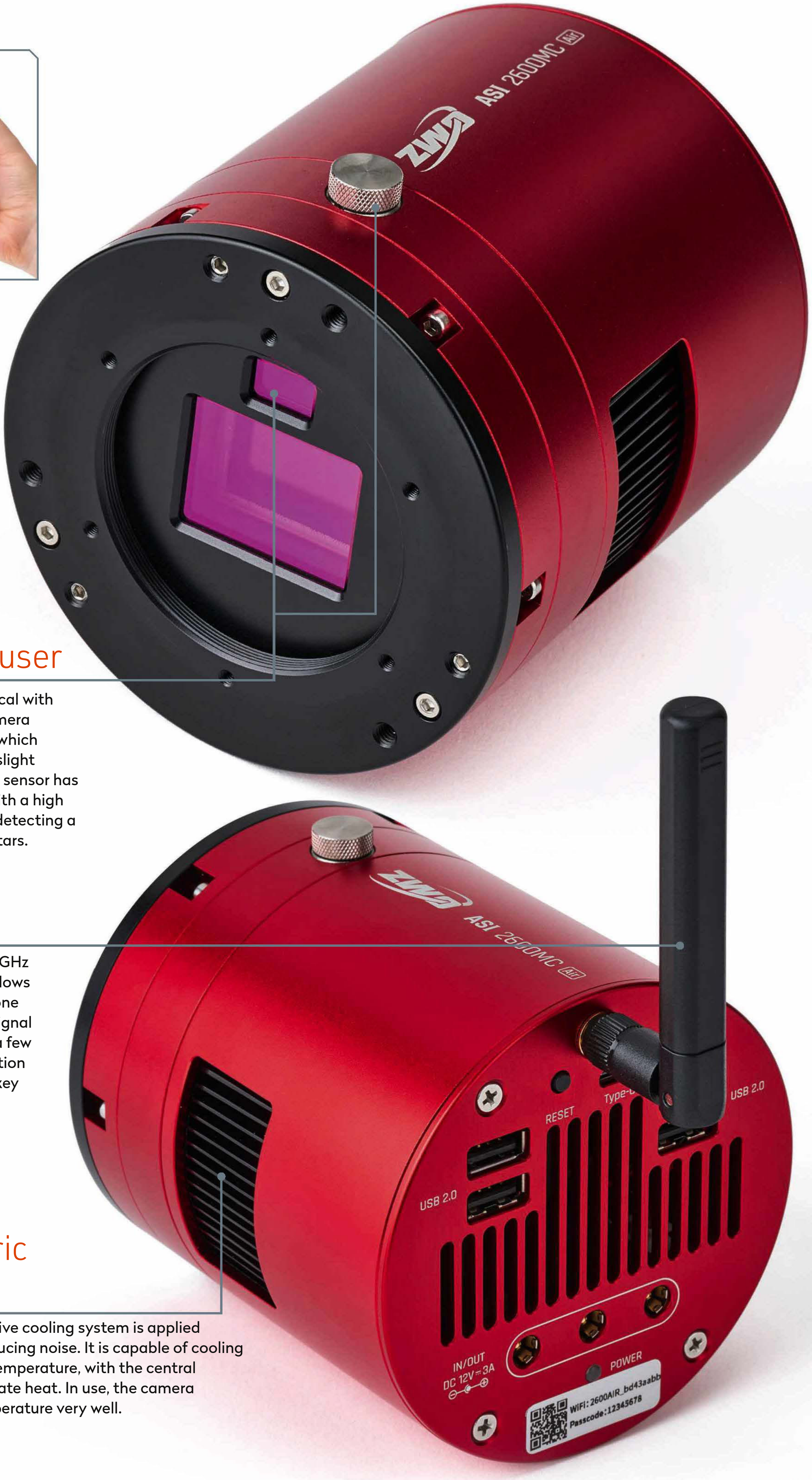
In contrast to many smart telescopes, the ZWO ASI2600MC Air does provide some degree of ▶



Main image sensor

The Sony IMX571 CMOS sensor provides an excellent imaging platform. It has a 6,248 x 4,176 array of 3.76μm pixels and is 28.3mm across the diagonal. As the beating heart of the camera, it reliably produces clean, low-noise images. Five-minute exposures taken with default gain settings provided great results.

ALL PICTURES: @THESHED/PHOTOSTUDIO


ZWO
ASI 2600MC Air
RESET
Type-C
USB 2.0
USB 2.0
IN/OUT
DC 12V⎓3A
POWER
WiFi: 2600AIR_bd43aabb
Passcode:12345678

Guide camera sensor and focuser

Although it's essentially parfocal with the main sensor, the guide camera benefits from its own focuser which allows for fine-tuning or even slight defocusing of guide stars. The sensor has a resolution of 1,920 x 1,080, with a high QE of 92 per cent, capable of detecting a wide range of suitable guide stars.

Built-in Wi-Fi

The camera emits a 5GHz/2.4GHz dual-band Wi-Fi signal that allows you to connect your smartphone or laptop to it. We found the signal to be strong and steady over a few metres' range and the connection to be fast enough to observe key details, such as autoguiding performance, in real time.

Thermo-electric cooling (TEC)

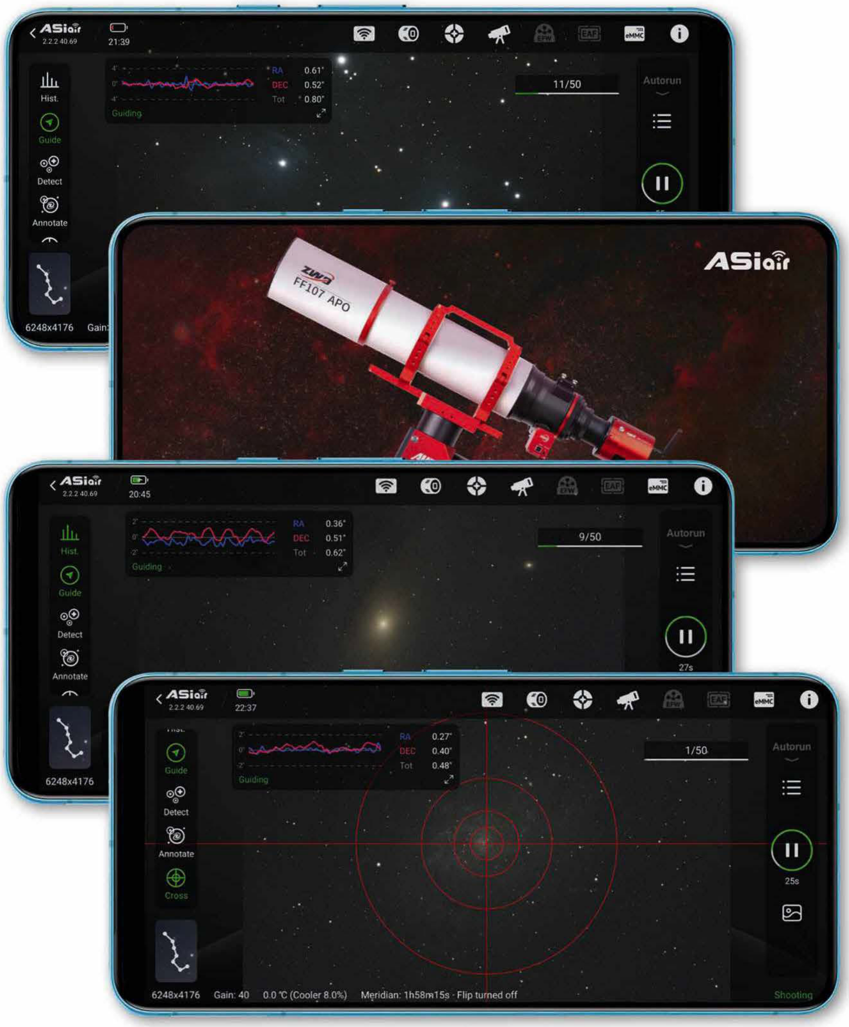
Controlled via the app, an active cooling system is applied to the main image sensor, reducing noise. It is capable of cooling to –35°C below the ambient temperature, with the central heatsink fins helping to dissipate heat. In use, the camera maintained our selected temperature very well.

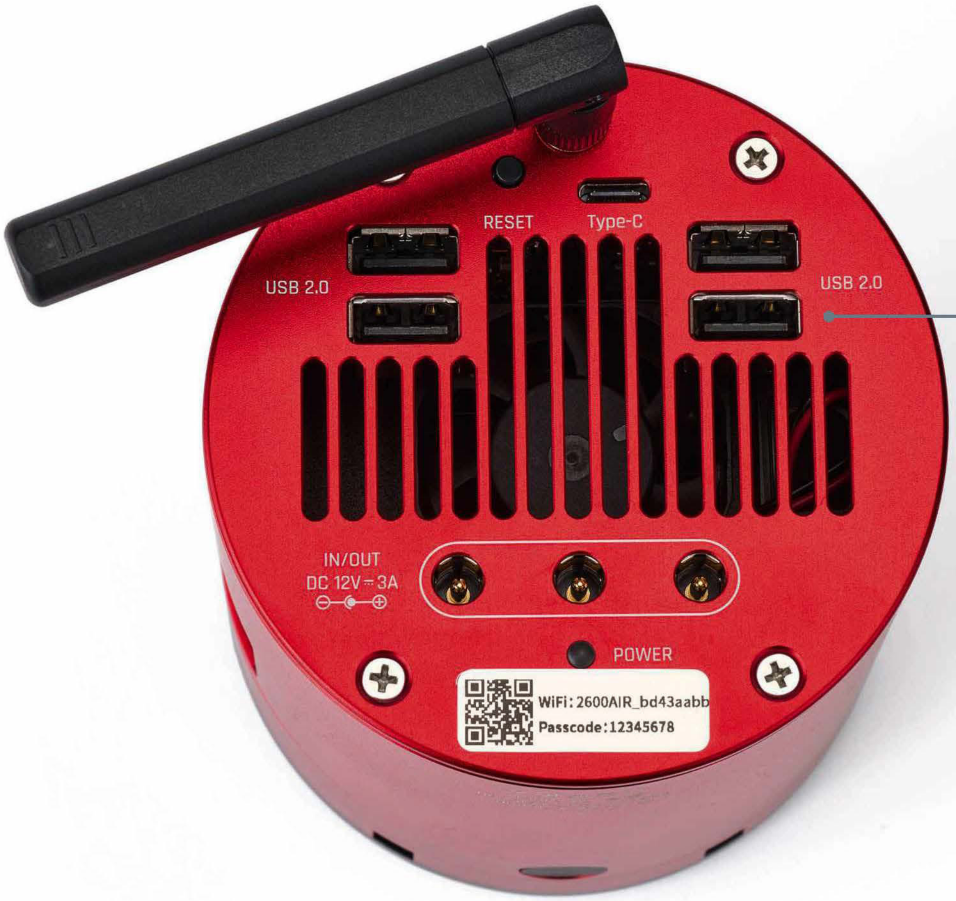
App makes imaging a cinch

The three-in-one ASI2600MC is already impressive, but combined with the wonderfully intuitive ASiair control app it sets a new benchmark for user-friendly astrophotography. From the moment you install the app on your device and connect to the ASI2600MC Air, you feel like you have a coach offering a helping hand, through useful prompts and tips. It perfectly complements the smart camera's physical features as it ties everything together in an easy-to-use platform.

The app is full of features. It helps you polar align your mount and performs autoguiding from the ASI2600MC's guide sensor via PHD2. There is a built-in Sky Atlas and once you choose your target, the app slews your mount into position and then takes a series of exposures while plate-solving them to accurately centre the mount. It also has a 'Live Stacking' feature for on-the-fly imaging and an 'Autorun' planning tool that allows a complete night's image scheduling, including darks and calibration files. With an easily navigable main screen, ZWO really has made astro-imaging simple with this capable app-enabled camera.

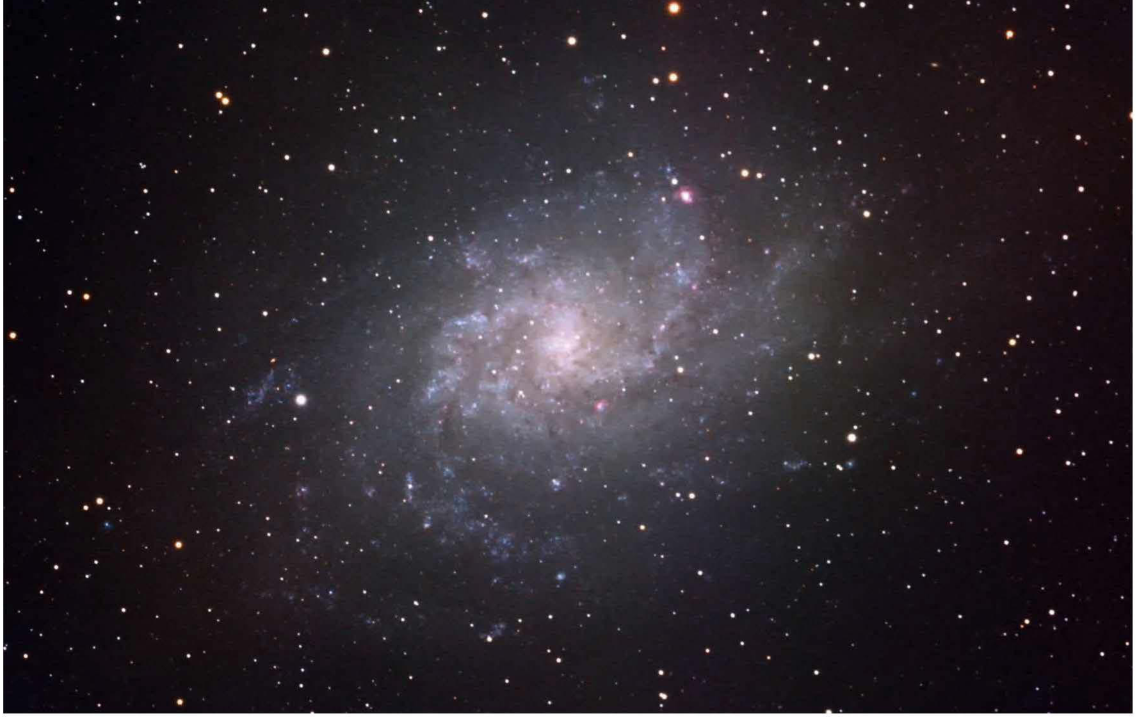
@THESHED/PHOTOSTUDIO, TIM JARDINE X7


ASiair
Hist.
Guide
Detect
Annotate
Cross
Guiding
RA
DEC
Tot
Autorun
11/50
9/50
1/50
ZWO FF107 APO
6248x4176
Gain: 40
0.0 ℃ (Cooler 8.0%)
Meridian: 1h58m15s · Flip turned off
Shooting

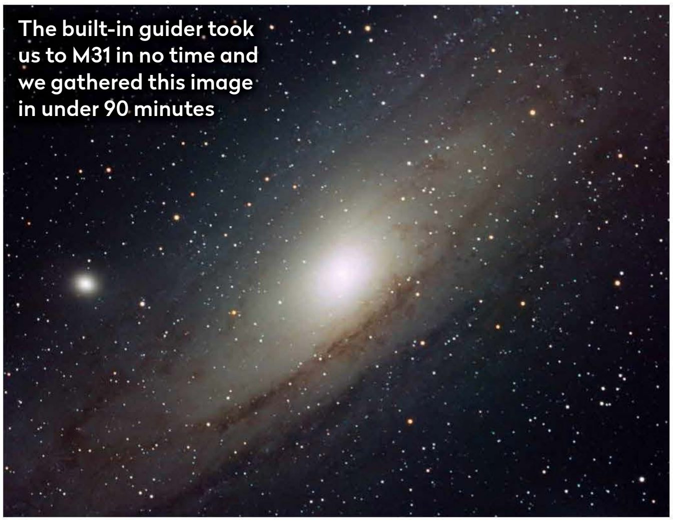

USB 2.0
RESET
Type-C
USB 2.0
IN/OUT
DC 12V⎓3A
POWER
WiFi: 2600AIR_bd43aabb
Passcode:12345678

USB & 12V power hub

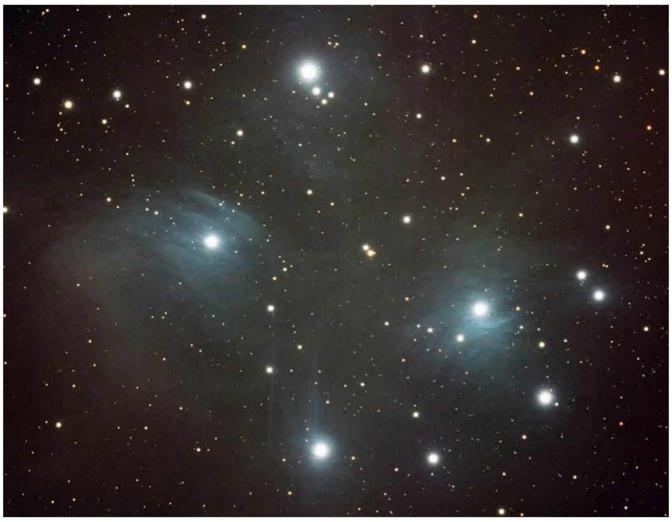
The ASI2600MC Air has three 12V sockets. When a 12V/3A–10A supply is connected to any of them, the other two become outlets which, along with the four USB slots, can be used to power and control accessories like a ZWO filter wheel or auto focuser, allowing shorter cables and a tidy imaging rig.



◀ With the help of the ASiair app, capturing the Triangulum Galaxy was simplicity itself. This is 1 hour and 48 minutes' worth of 180-second exposures



The built-in guider took us to M31 in no time and we gathered this image in under 90 minutes



▲ The Pleiades looking fabulous from 2 hours of 5-minute exposures. The ASI2600MC Air was paired with a Sky-Watcher Esprit Pro 150ED on a GM1000 mount for all images

▶ flexibility, as you can choose your own mount, plus it's compatible with any telescope that provides a 44mm or larger image circle to cover both sensors. This means it has far fewer limitations than a smart telescope while providing every feature necessary to make a fairly technical hobby less complicated.

With weather patterns in recent times often proving unpredictable, an opportunity to quickly set up and take advantage of clear spells is much appreciated, and this camera allowed for one of the fastest set-ups of a separate mount, telescope and camera combination that we have experienced. In no time, we were polar aligned and ready to start our imaging session.

Effortless excellence

As far as the results go, the reputation of the Sony IMX571 main imaging sensor is well-established. It has a peak quantum efficiency (QE) of 80 per cent, does not suffer from amp glow issues and the 16-bit ADC ensures there is plenty of dynamic range to capture the faintest objects alongside the brightest.

We chose familiar targets like the Pleiades, and the Andromeda and Triangulum galaxies, where the ASI2600MC Air faithfully captured every detail the conditions allowed. The bright core of Andromeda was nicely controlled, alongside its intricate dust lanes. As this is a one-shot colour camera, there's no need for extra filters, although you can add and control a ZWO filter wheel via the ASiair app, if desired. Once the images were captured in the camera's built-in 256GB memory, we simply inserted a USB flash drive and transferred them, ready for separate stacking and processing as normal. There is also the option to connect the camera directly to your PC and use it like a USB drive.

With the three-in-one camera, autoguider and complete image-capture package contained in the ASI2600MC Air, ZWO has certainly made high-quality astrophotography less daunting to newcomers. In our opinion, even experienced astrophotographers will find that this clever device will drastically simplify their hobby while returning impressive imaging results.

VERDICT

Build & design	★★★★★
Connectivity	★★★★★
Ease of use	★★★★★
Features	★★★★★
Imaging quality	★★★★☆
OVERALL	★★★★☆

KIT TO ADD

1. 12V/5A main power supply for ZWO cooled cameras

2. ZWO filter drawer

3. ZWO M54 tilter

Our experts review the latest kit

FIRST LIGHT

StarField Optics Gear60 quad f/5 Petzval apo

This compact scope excels for sharp nebulae, galaxies, comets and more

WORDS: MARY MCINTYRE

VITAL STATS

- **Price** £849
- **Optics** Petzval four-element (two-element FPL53 ED glass objective; two-element corrector)
- **Aperture** 60mm
- **Focal length** 300mm, f/5
- **Focuser** 2.5-inch dual-speed rack and pinion
- **Extras** Soft carry case, carry handle, dovetail bar
- **Weight** 3.1kg
- **Supplier** First Light Optics
- **Email** questions@firstlightoptics.com
- **www.** firstlightoptics.com

Refractors are versatile instruments that can be used for photographing a variety of astronomical objects. Small-aperture fast-focal-ratio refractors really come into their own when we image large, faint objects such as nebulae or large galaxies. StarField Optics' Gear60 is an f/5 telescope boasting Petzval four-element optics, so we were looking forward to seeing how well it stacked up in our tests.

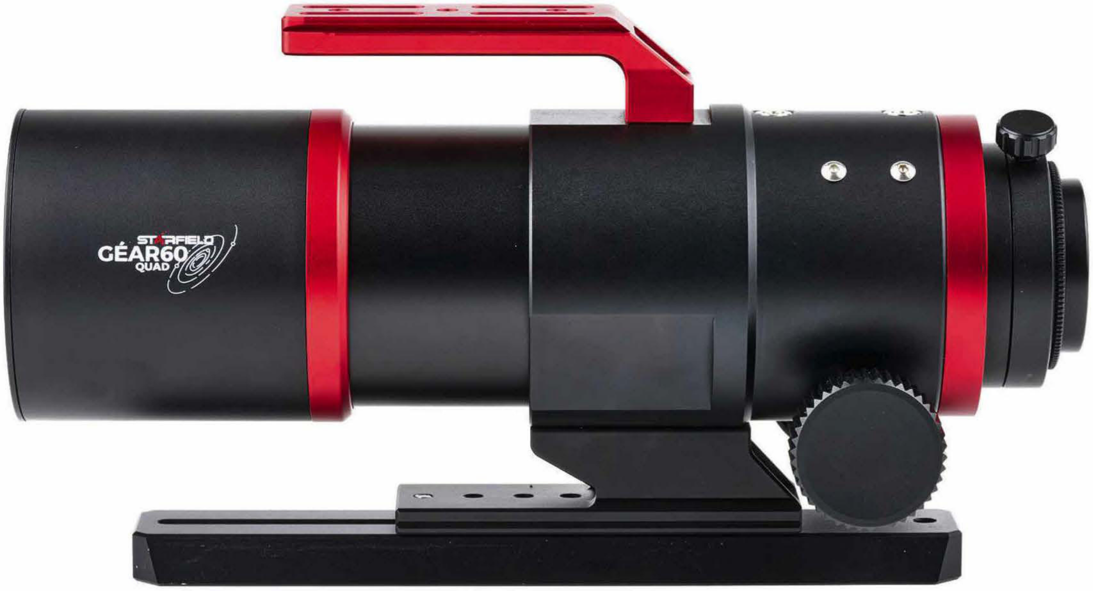
The compact refractor arrived in a sturdy box stored in a compact soft carry case with a shoulder strap. We noted the case was fully lined with die-cut foam, ensuring the telescope would be kept safe in transit, and that it even had additional spaces to accommodate accessories such as an after-market electronic focuser or camera equipment.

First impressions were that the Gear60 is beautifully manufactured, with all-metal parts and very secure metal dust caps. We found the black-and-red colour scheme particularly striking. Although very compact when the dew shield is retracted, the telescope weighs 3.1kg, so the carry handle on the top is a welcome addition. We added our own red dot finder onto one of the two available mounting points and prepared for clear skies.

The weather during the review period was not ideal, but the compact size of the telescope made it quick and easy to mount, so we were able to grab moments to image a variety of objects with four different cameras. When extended, we thought the dew shield gave great protection from lens fogging, but we added an external dew heater for peace of mind.

Optics impress us

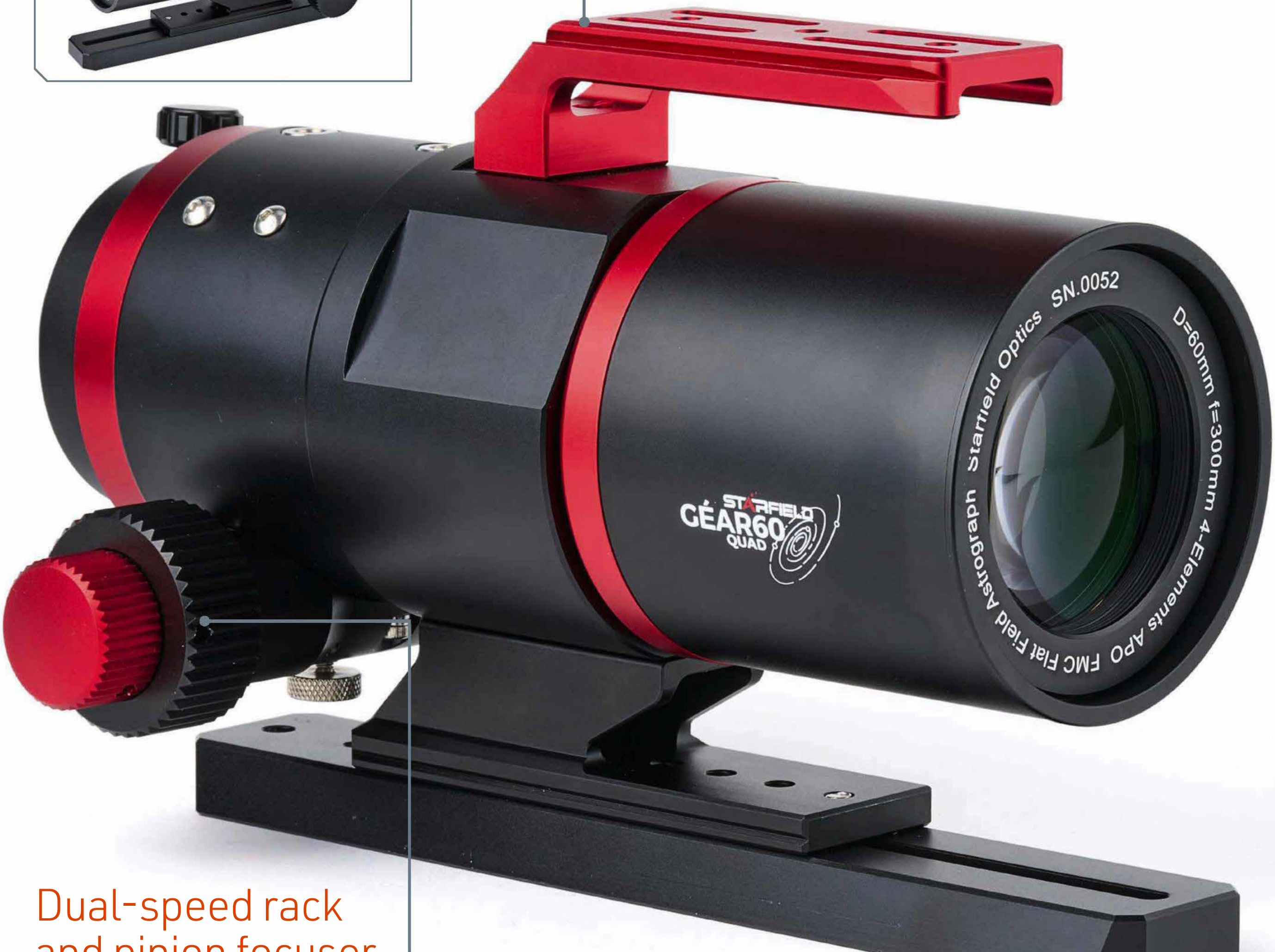
On the first clear night, we mounted an entry-level astronomy-modified DSLR camera to photograph the Flaming Star Nebula over 90 minutes. The optics were very impressive and the resulting images had amazing clarity. The Gear60 was so fast that we were able to use a lower ISO for this faint object, which helped to reduce noise – a huge advantage for those of us with budget or older camera models. ▶



@THESHED/PHOTOSTUDIO X 3, MARY MCINTYRE X 4

Carry handle

The dual-purpose carry handle not only aids with lifting and carrying the telescope, but can also be used to mount additional accessories such as a guidescope or camera. It is pre-drilled with three threaded holes that take the standard 1/4-inch camera mounting screw.

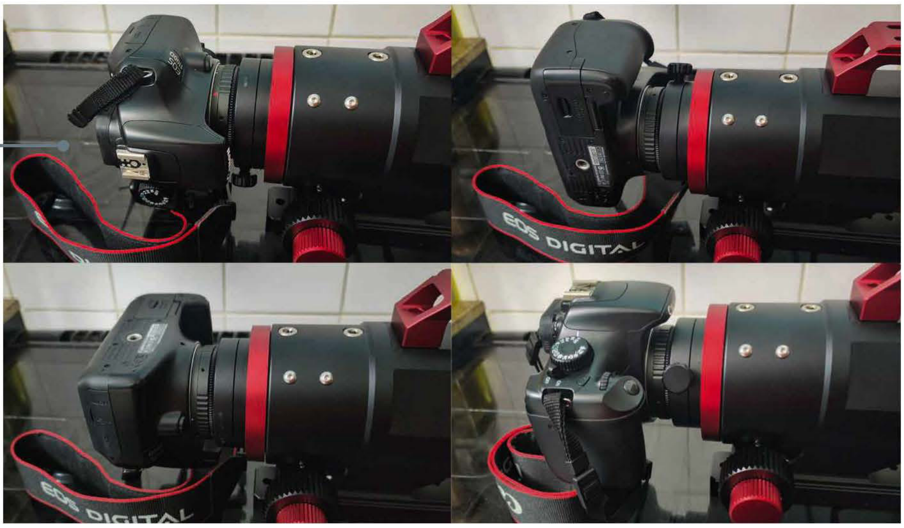

STARFIELD
GEAR60
QUAD
Starfield Optics SN.0052 D=60mm f=300mm 4-Elements APO FMC Flat Field Astrograph

Dual-speed rack and pinion focuser

The 2.5-inch dual-speed rack and pinion focuser has a 10:1 gear reduction for fine focusing. The drawtube is supported by ball bearings which provide stability when heavier DSLR cameras are attached. Allowing 20mm of travel, its focusing is extremely smooth, with no slippage during adjustment. A focuser dust cover and locking screw are included.

360° camera rotator

Some objects need to have the camera orientated in a particular way for the best framing. The 360° rotator allows for fully adjustable framing of the imaging target without the need to loosen and rotate the camera itself, a feature that prevents loss of focus.



Quality quad design

The Gear60's Petzval four-element design – a two-element objective lens with FPL53 ED glass, plus a two-element corrector – ensures this scope is optimised for astrophotography. Its optical arrangement allows DSLR cameras to be screwed on securely with an M48 x 0.57mm thread adaptor without the need for a spacer. Alternatively, the nosepiece of CMOS and CCD cameras can be attached. This ensures optimal sharpness across the entire field of view, while its 44mm image circle allows full illumination of full-frame DSLR sensors.

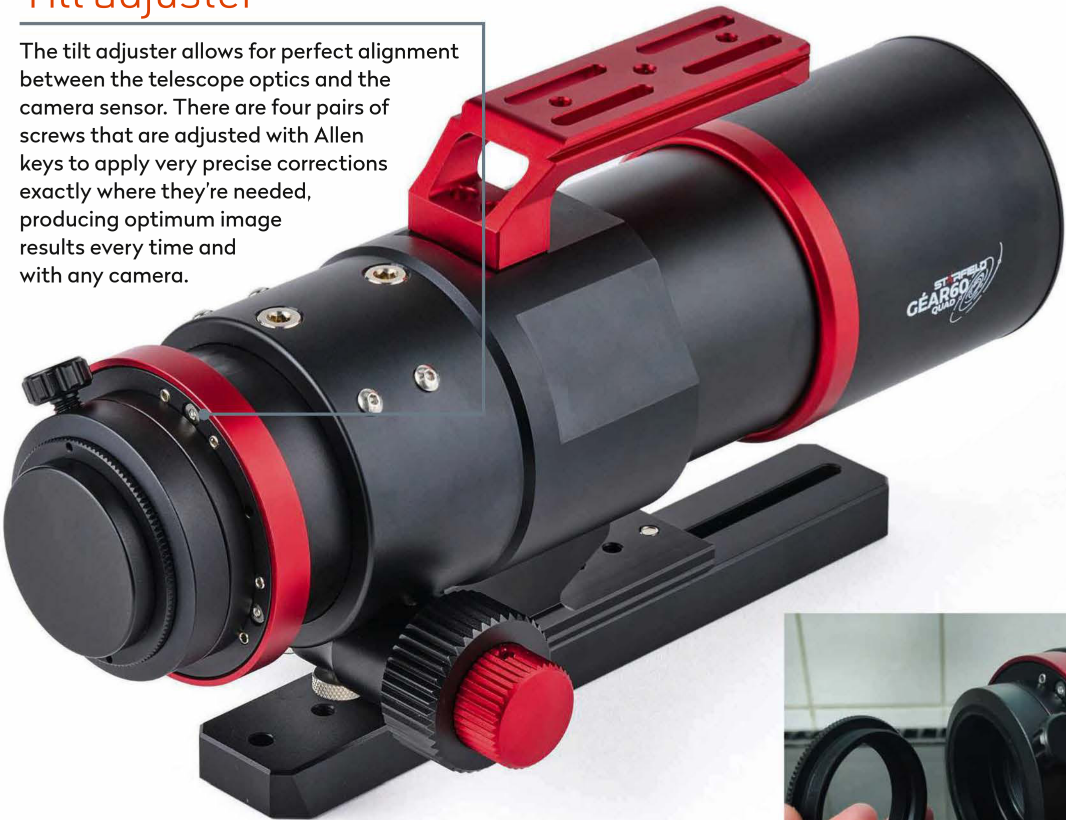
The images had pin-sharp stars across the whole field and were free of any kind of optical or chromatic aberrations, even when an entry-level camera was used in less-than-ideal observing conditions. The working distance is 41mm to 61mm and we were able to achieve focus both at the native focal length and also with a 2x or 3x Barlow in the imaging train, which makes it a solid option for lunar photography, as well as deep-sky. While an extension tube was required when we used a 5x Powermate for Jupiter, the images were still impressively clear.

@THESHED/PHOTOSTUDIO X 2, MARY MCINTYRE X 6

Starfield Optics SN.0052
Astrograph
FMC Flat Field APO 4-Elements

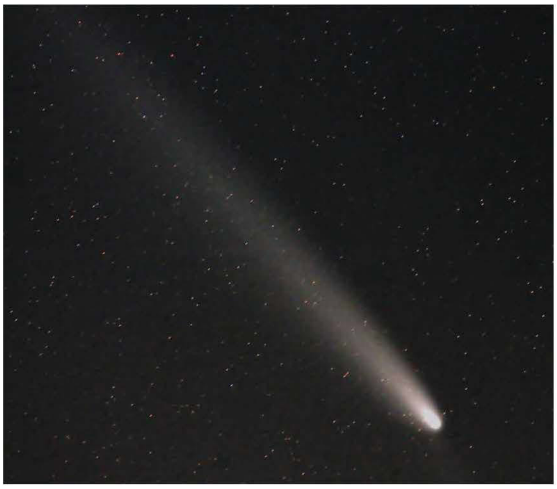
Tilt adjuster

The tilt adjuster allows for perfect alignment between the telescope optics and the camera sensor. There are four pairs of screws that are adjusted with Allen keys to apply very precise corrections exactly where they're needed, producing optimum image results every time and with any camera.

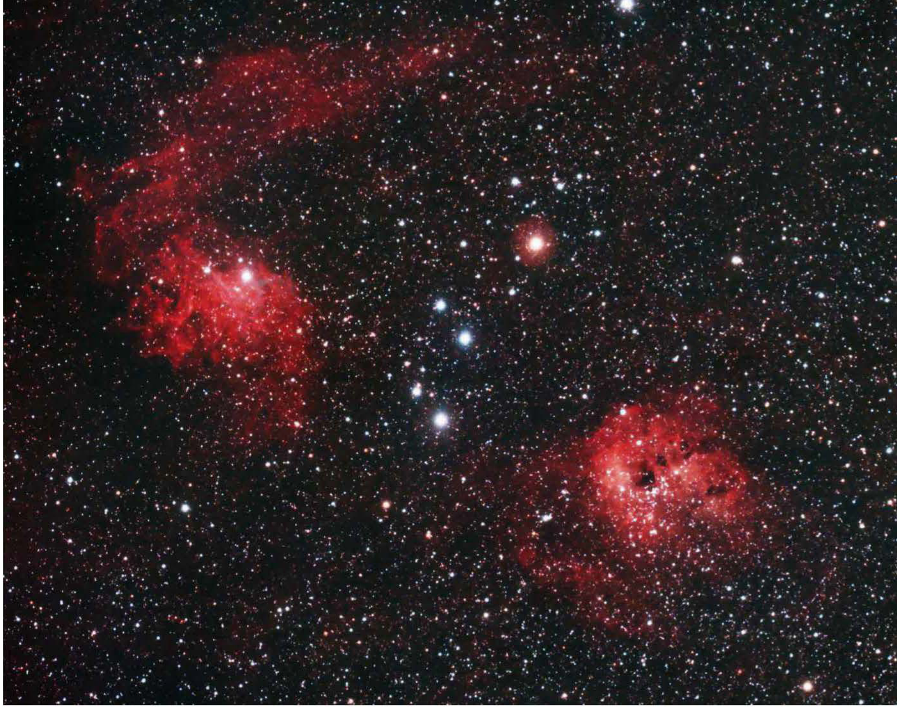


Integrated 2-inch filter holder

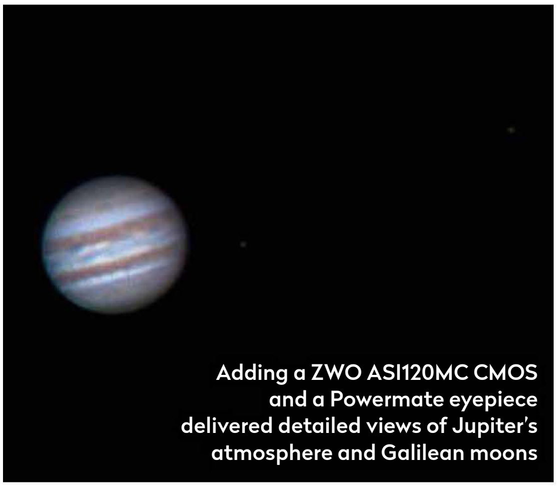
The filter holder is well made, with excellent-quality screw threads. It places the filter in front of the camera, so you can use it with cameras with either 2-inch or 1.25-inch nosepieces (with the right adaptor; always make sure that the nosepiece doesn't protrude and hit the filter).



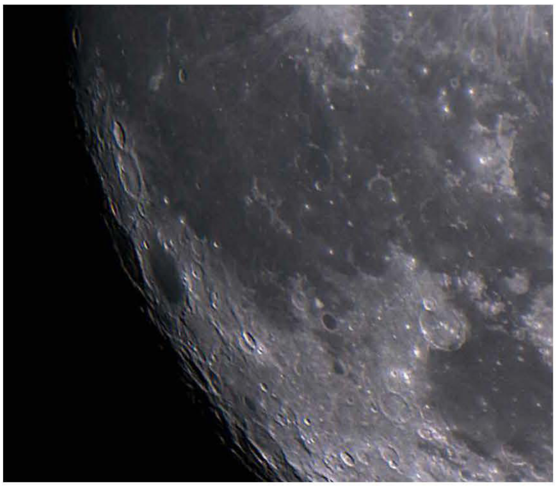
▲ **Comet C/2023 A3 (Tsuchinshan–ATLAS) taken with a Canon 1100D on board the Gear60, ISO 800, 7x 20"**



▲ **Faint objects were pleasingly noise-free even with low ISOs: the Flaming Star Nebula taken with an astro-modified Canon 1100D at ISO 800, 53x 90"**



Adding a ZWO ASI120MC CMOS and a Powermate eyepiece delivered detailed views of Jupiter's atmosphere and Galilean moons



◀ **We loved the sharpness and clarity in lunar landscapes, like these craters on the western limb taken with a ZWO ASI120MC and 3x Barlow**

▶ When the skies cleared again, we used a non-modified entry-level DSLR to capture 2.5 minutes on comet C/2023 A3 (Tsuchinshan–ATLAS), 45 minutes on the Triangulum Galaxy and 30 minutes on the Pleiades. Despite thickening fog, the results were still impressive with no sign of chromatic aberration around the stars or deep-sky targets.

Ably avoids aberrations

On our final night of imaging, we mounted a budget CMOS camera to the Gear60 to capture an almost 100%-illuminated Moon, first at the native focal length and then with a 3x Barlow lens. Again, no colour fringing was present and the resulting lunar images were lovely and sharp. We couldn't resist testing it by photographing Jupiter with a 5x Powermate eyepiece in the imaging train. Although still quite small on the camera sensor, some lovely details in the planet's cloud belts were captured, while three Galilean moons were clearly visible.

Finally, we switched to a mid-range, fan-cooled, deep-sky CMOS camera and managed to capture 10.5 minutes on the Orion Nebula before clouds rolled in. Despite such a short total exposure time, the results were still very impressive.

The Gear60 also features a built-in filter holder, which is a great addition but also very slim and difficult to grip with cold hands, which makes it tricky to unscrew the filter holder and camera mounting ring independently. To reduce the risk of dropping an expensive filter, we found it easier to screw everything together indoors in the warm and then use the carrying handle to take the whole assembly outside to cool down before imaging.

With deep-sky and narrowband imaging, every photon counts, so the StarField Gear60's excellent f/5 optics make this an ideal choice for capturing nebulae, large galaxies and comets. However, it's also versatile enough for imaging other objects. While it's not suitable for visual observing, it's certainly a great option for anyone serious about small-aperture astrophotography.

VERDICT

Build & design	★★★★☆
Ease of use	★★★★☆
Features	★★★★★
Imaging quality	★★★★★
Optics	★★★★★
OVERALL	★★★★☆

KIT TO ADD

1. Astro Essentials M48 DSLR adaptor
2. StarField 32mm guidescope
3. Sightron 2-inch quad narrowband filter

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Parkdean Resorts

Charlotte Daniels rounds up the latest astronomical accessories

GEAR

1
2
3
SPACE TRAVEL
4
ALTAIR
Male M42x0.75
5
ZOOM EYEPIECE 7.2mm 53°
6

1 Astro Essentials eyepiece case

Price £45 • **Supplier** Harrison Telescopes
www.harrisontelescopes.co.uk
The longer we spend as astronomers, the more accessories we seem to amass! This versatile case measuring 37 x 24 x 15cm will keep your eyepieces, Barlow lenses and filters in one snug place, thanks to its pre-cut foam holes.

2 Dryrobe thermal gloves

Price £40 • **Supplier** dryrobe
www.dryrobe.com
Winter astronomy can be challenging, with frosty nights making it tricky to operate equipment. Ensure numb fingers are a thing of the past with these mitten-style gloves. Fleece-lined and water resistant, they have flaps that simply fold back whenever you need to be dexterous.

3 Moon mug

Price £25.49 • **Supplier** Science Gifts UK
www.science-gifts.co.uk
These embossed ceramic mugs are both a striking and practical nod to our love for astronomy, boasting a lid and cleverly concealed spoon within the interstellar design. Available in blue, pink and white.

4 Magnetic filter holder combo sets

Price £90 • **Supplier** Altair Astro
www.altairastro.com
Filter drawers allow you to swap in single filters to an imaging train without the need to purchase a full filter wheel. Altair's combo set features a filter holder and two filter sliders within a neat package. Available for 1.25- and 2-inch filters, with M48 or T2 attachments.

5 Lunt LS7-21ZE zoom eyepiece

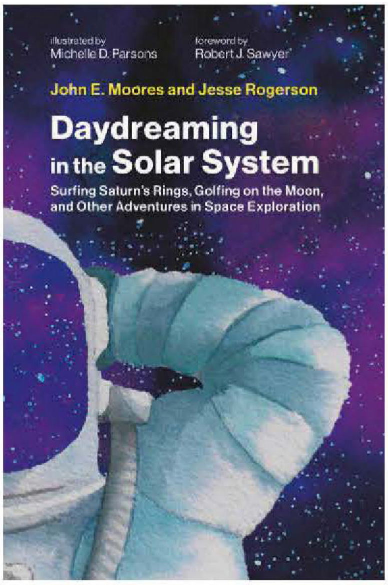
Price £349 • **Supplier** Bresser
www.rothervalleyoptics.co.uk
Zoom eyepieces are an efficient accessory, offering the flexibility to view a range of objects with a single item. Lunt's 7.2mm–21.5mm version with 1.25-inch barrel has a field of view between 40° and 53°, and multicoated optics for optimal field and colour correction.

6 Acuter MaksyGo 60 mini Dobsonian

Price £99.99 • **Supplier** The Widescreen Centre
www.widescreen-centre.co.uk
The design of this dinky Dobsonian is rather novel. A removable discovery panel on the side allows you to see the internal structure of the Maksutov–Cassegrain telescope and learn how it works. Introduce little ones to astronomy with this fully functional set, featuring eyepieces, diagonal and smartphone adaptor.

New astronomy and space titles reviewed

BOOKS


illustrated by
Michelle D. Parsons
foreword by
Robert J. Sawyer
John E. Moores and Jesse Rogerson
Daydreaming in the Solar System
Surfing Saturn's Rings, Golfing on the Moon, and Other Adventures in Space Exploration

Daydreaming in the Solar System

John E Moores and Jesse Rogerson
MIT Press
£30 ● HB

It's only human to wonder what it would be like to stand on the surface of Mars or fly around an asteroid. What *Daydreaming in the Solar System* does is add a large amount of 'flesh' to those space dreams through short stories. But the dreams are based in solid physics, and the explanations make up the second part of each chapter.

As the reader (and protagonist) of the stories, we start each chapter immersed in an alien environment at some indeterminate point in the future. In one chapter we're working on the Moon, in another mining a comet, sailing on the Titanian seas or exploring the ocean of the moon Europa. Engineering isn't considered an obstacle, but the human elements of life remain, even if that's just making a cup of coffee, which is as challenging in the high-pressure atmosphere of Titan as it is at high altitude on Earth!

In most cases, the activities are part of scientific experiments or expeditions, such as fossil hunting on Mars or sampling the gases in Jupiter's Great Red Spot, but now and again we find ourselves in more frivolous pursuits, like balloon races around Venus or sledging down the icy mountains of Pluto on our way to view the sunrise.

The need to explain the science in the second half means there's sometimes a bit more exposition involved than you might find in a standard science-fiction short story. But such details help us imagine what these worlds would be like, aided by some beautiful pictures.

The non-fiction parts are nicely detailed, helping explain how we know what we know about these worlds. We explore the optical effects in atmospheres of different compositions, and what sailing, flying or gliding would be like in a medium of a different density and under different gravity. There are a few graphs and equations, so this isn't for the completely uninitiated, but everything is well explained with helpful diagrams.

Dreaming of fossil hunting on Mars and sledging on Pluto? This book explores how that would really go

If you've ever wondered what it would be like to explore the Solar System, but with some basis in fact, this is a wonderful way to put yourself in the shoes – or spacesuit – of a daydreamer of the future. ★★★★★

***Chris North** is head of public engagement at Cardiff University School of Physics and Astronomy*

DOTTEDHIPPO/ISTOCK/GETTY

Interview with the author
John E Moores

If you could visit anywhere in our Solar System, where would you go?

There are so many fascinating places, it's hard to pick a favourite! We did our best to cover the highlights, from flying on Titan to mountaineering on Pluto. But if forced to make a choice, I would go for something truly alien to our human senses: getting up close and personal with the rings of Saturn. Here, I'd love to join in the gravity-driven dance of the many icy blocks that make up this huge structure.

What body is overdue a new mission?

We haven't been to the surface of Venus in 43 years. In fact, we've never been to the highlands, where recent research suggests we might find evidence of the vanished Venus that existed before greenhouse warming transformed the planet. While there has been renewed interest in this world with the Venus Express and Akatsuki missions, and good pathfinders upcoming with DAVINCI and VERITAS, there are no plans currently to return to the surface.

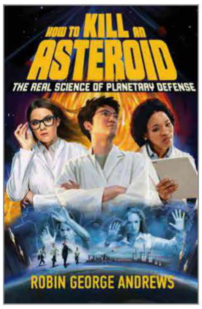
What mysteries would you love to see solved?

I'm fascinated by what might lie below the cracked icy shells of Jupiter's moons Europa and Ganymede, as well as Saturn's Enceladus. The oceans within these moons represent the largest habitable volume in our Solar System. But are they inhabited? The answer could transform the way we think about life in our Universe. I hope I'll have the chance to know the answer in my lifetime.

***John E Moores** is an associate professor in the Centre for Research in Earth and Space Science at York University*

How to Kill an Asteroid

Robin George Andrews
WW Norton
£19.99 ● HB



Killing an asteroid to prevent cosmic catastrophe. That sounds like science fiction, right? Sure enough, the cover of this wonderful book resembles a Hollywood sci-fi blockbuster poster. But any resemblance to real persons and events is actually very much intentional. Volcanologist and science writer Robin George Andrews tells the captivating true story of NASA's DART mission, humanity's first – and incredibly successful – planetary defence experiment. And it's actually much better than *Armageddon* or *Deep Impact*.

The facts are well known: on 26 September 2022, DART (the Double Asteroid Redirection Test) slammed into Dimorphos, the tiny satellite of asteroid Didymos, substantially altering the rubble pile's orbit. In the future, a similar mission might be necessary to divert a small 'city-killer' asteroid on a collision course with Earth.

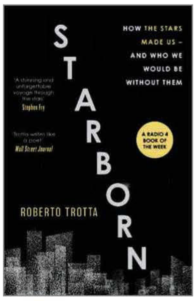
How to Kill an Asteroid provides a wealth of background and behind-the-scenes information, as well as many excursions into related topics. Andrews is a marvellous and witty storyteller who vividly portrays all major players in the field and catches us up on meteorites, asteroids and comets, impact craters and space missions. We also learn about the dreadful consequences of a celestial direct hit – something we really would need to prevent, as the author makes clear in his vivid description of an (imaginary) cosmic impact devastating Seattle.

This is a scientific page-turner that builds up to a great climax and is written in an accessible and entertaining style, yet chockful of serious information. A direct hit, I'd say. ★★★★★

***Govert Schilling** is an astronomy writer and author*

Starborn

Roberto Trotta
Basic Books
£10.99 ● PB


STARBORN
HOW THE STARS MADE US – AND WHO WE WOULD BE WITHOUT THEM
ROBERTO TROTTA
A RADIO 4 BOOK OF THE WEEK

Swiss psychiatrist Carl Gustav Jung once asked: "What have we to do with the stars?" According to this erudite and beautifully written book, the answer is 'everything', from when sky-savvy sapiens, seated around campfires, first gazed skyward, to the present era of space exploration and AI technology. With night skies increasingly light-polluted and littered with artificial satellites, the stars are becoming lost to us. This disconnection may lead to the eventual destruction of planet Earth, the precious 'pale blue dot' upon which all life depends.

The author's rich, lyrical text takes us on a deeply personal and insightful journey from the pit of our past, when biped life forms borne of stardust scurried around in caves, scraping with stone tools but painting stars on the walls. Omnipresent throughout history, stars have variously been adored and worshipped as gods, used for navigation and timekeeping, as a calendar and almanac, in literature, and ultimately induced a mathematical and scientific revolution. But at what cost? Are we victims of our own success? Do we now seek to live elsewhere in the Galaxy to save ourselves from self-destruction, escaping, ironically, the 'demon megamachine' wrought by the technology that our study of the stars has brought about?

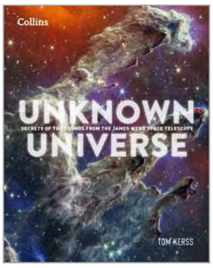
This book asks us to draw upon our ancestral links to the sky to reignite awe and wonder, to truly reconnect with the stars and regain vital perspective. It also offers a sober and salutary warning, a powerful plea for preservation in an era of disenfranchisement. It is, therefore, an essential read, for everyone. ★★★★★

***Jane Green** is an astronomy communicator and author of the* Haynes Astronomy Manual

WEBB SCIENCE

Unknown Universe

Tom Kerss
Collins
£16.99 ● HB



The James Webb Space Telescope has wowed us with breathtaking glimpses of the cosmos, revealing its endless beauty and wonder in recent years.

Tom Kerss's book, *Unknown Universe: Secrets of the Cosmos from the James Webb Space Telescope*, takes us on a captivating journey through the cosmos by compiling the telescope's awe-inspiring images in one immersive experience.

Kerss begins by offering a brief overview of the JWST, tracing its journey from initial concept to construction and eventual launch. What really sets this volume apart from other picture-heavy books of this type is that the author also highlights the telescope's onboard instruments that capture the stunning images, giving readers a glimpse into its inner workings and enhancing our understanding before we delve into the trove of captivating imagery.

Particularly charming is Kerss's masterful blending of stunning visuals and engaging educational content. His concise and accessible commentary makes the material both easy to grasp and utterly fascinating to read.

We're treated to stunning double spreads of some of the JWST's best images so far, such as its amazing view of the Tarantula Nebula. Solar System objects feature too, like a spectacular image of Saturn's rings, glowing in infrared. Another nice touch is the side-by-side comparison of the Ring Nebula, showing the contrasting views achieved by the NIRCam and MIRI instruments.

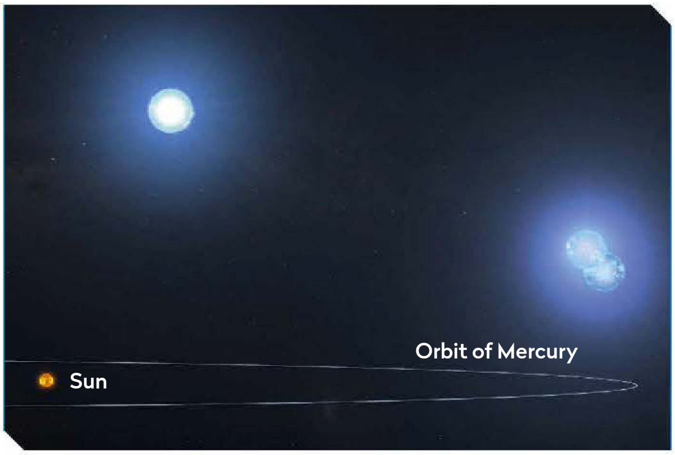
Unknown Universe is an insightful introduction to the James Webb Space Telescope and a wonderful window into the realms of the unseen cosmos. Each page leaves you eager to turn to the next one and continue the journey. ★★★★★

***Melissa Brobby** is digital communications officer at the UK Space Agency*

Anita Chandran talks to Dr Veselin Kostov

Q&A WITH A STELLAR ECLIPSE SPECIALIST

Many stars are gravitationally locked inside multi-star systems, but a rare new triple-star system has set a new record for how cosy these clusters can get



▲ To give an idea of just how close the stellar triplets orbit one another, this illustration overlays the TIC 290061484 system on our own Solar System

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What is a triply eclipsing three-star system?
While orbiting their parent star(s), planets can sometimes cross the line of sight between the star and Earth. When they do, they produce a 'transit' that we can detect. Eclipsing star systems are similar. Instead of a planet, a star moves in front of another star, blocking some of its light. Triply eclipsing three-star systems consist of three stars orbiting a common gravitational centre. Two stars closely orbit one another, and both orbit a more distant third star. Sometimes, from Earth we can detect three sets of eclipses from these systems.

What did your study discover?
We discovered a triply eclipsing three-star system called TIC 290061484, consisting of a pair of inner stars orbiting one another in about 1.8 days and a third star in a wider orbit of around 24.5 days.

What is significant about TIC 290061484?
It's the shortest known orbit in a triple system, by far. The previous record-holder, Lambda Tauri, was discovered over 60 years ago and had an outer orbit of 33 days. Since then, many people have looked for even shorter outer periods.

Now we've found TIC 290061484, the question remains: what is the shortest orbit possible in such a system? Physics tells us that a binary star system with a one-day period can have a companion third star with an outer period of 10 days. Only a very small fraction of triple-star systems are eclipsing, because they need to be in the correct orientation to Earth for the stars to move in front of one another along our line of sight, so the chance of finding one is tiny.

How did you discover TIC 290061484?
In several stages. The first stage relied on machine learning to examine all the available data taken by the Transiting Exoplanet Survey Satellite (TESS). The 'robots' sift through tens of millions of stars and tag hundreds of thousands of potential eclipsing two-star systems. These are sent to a team of trained citizen scientists who visually inspect the data for signs of additional eclipses and other unexpected phenomena. Humans are exceptionally good at quickly and reliably identifying these! Our team then makes detailed simulation models to confirm the system is what we think it is.

What is TESS?
It's a survey mission that observes the entire sky in slices. It's designed to find transiting exoplanets, but it's also an excellent detector of variable astrophysical sources such as Solar System asteroids, eclipsing binaries, supernovae and active galaxies. This makes TESS data ideally suited for detecting multiple-eclipsing star systems.

Tell us more about how citizen science helped
A Zooniverse group called the Visual Survey Group has worked together for more than a decade to examine data from each star system visually. The data is called a light curve, which shows how the brightness of a star changes with time. Roughly speaking, sudden dips in the light curve can indicate an eclipse, and this is what the Visual Survey group looks for. Since they began working together, they've inspected tens of millions of light curves from Kepler, K2 and TESS.

What's significant about these triple-star systems?
Studying these systems gives us a better idea of how such compact systems can form. We have no definitive answers, but modelling such triple systems gives us the opportunity to conceptualise different formation and evolution pathways. For example, in TIC 290061484, all the stars are quite massive and will evolve rather quickly. We expect that in about 20 million years the system will explode as a supernova, seeding the Galaxy with heavy elements and leaving behind a single neutron star.

What's next for your team?
Beat our own record! We're already planning for the next satellite mission, the upcoming Roman Space Telescope, which could enable the detection of even shorter-period triple stars. We will also be looking for other interesting systems, not just triples but higher-order star systems with four, five, six or even more sets of eclipses.

Veselin Kostov is a research scientist at the Search for Extraterrestrial Intelligence (SETI) Institute, working on the discovery and characterisation of exoplanets and multiple-star systems

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

Keep watch for fireballs with long-lasting trains during this month's Moon-free Alpha Centaurids

When to use this chart

1 Feb 00:00 AEDT (31 Jan, 13:00 UT)
15 Feb 23:00 AEDT (12:00 UT)
28 Feb 22:00 AEDT (11:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

JANUARY HIGHLIGHTS

The Alpha Centaurids meteor shower is active 28 January–21 February and ideal for Southern Hemisphere observers. The maximum rate of 6 meteors per hour is expected just before dawn on the 8th. The radiant, near the Southern Pointers, will be quite high in the early hours, with morning leading up to the peak mostly Moon-free (first quarter on 5th). This shower can produce yellow/blue fireballs, often reaching negative magnitudes, with trains lasting from seconds to minutes!

STARS AND CONSTELLATIONS

The upside-down hunter of Orion is prominent in the northwest evening sky, with the first-magnitude blue 'foot' star, Rigel, above (south) and his red 'armpit' star, Betelgeuse, below (north). Following Orion faithfully are his two hunting dogs: Canis Major (Greater Dog), best known for the brightest star, Sirius, high in the north; and Canis Minor (Lesser Dog) to the lower right, recognised by the star Procyon. These stars form an equilateral triangle with Betelgeuse.

THE PLANETS

February is the last chance to glimpse Saturn and Venus, low in the western twilight, before they go into solar conjunction. Find the crescent Moon near Saturn on the 1st and Venus the following night. As twilight closes, Uranus is low in the northwest, near the Pleiades, followed by Jupiter in Taurus, brilliantly outshining nearby Aldebaran. The evening planetary parade continues, with Mars due north around 22:00, brighter and redder than the adjacent Gemini twins, Castor and Pollux.

DEEP-SKY OBJECTS

The constellation of Volans is sandwiched between the Milky Way and the Large Magellanic Cloud (LMC). The naked-eye star Gamma (γ) Volantis (RA 7h 08.5m, dec. –70° 32') is a brilliant double with mag. +3.8 and +5.6 components, distinctively yellow and white respectively, 14 arcseconds apart. About a binocular field away (5.5° to the east-northeast) lies another impressive double, Epsilon (ε) Volantis. It's composed of mag. +4.4 and +7.9 stars, blue and yellow respectively, a snug 7 arcseconds apart.

Between Gamma and Epsilon is the mag. +10.6 Meat Hook Galaxy, NGC 2442 (RA 7h 36.3m, dec. –69° 35'). A 200mm scope reveals a distinct centre bar (1 x 3 arcminutes) and a stellar nucleus pointing to a 1-arcminute-wide patch. Although it looks detached, it's part of a bright narrow arm of NGC 2442, called NGC 2443.

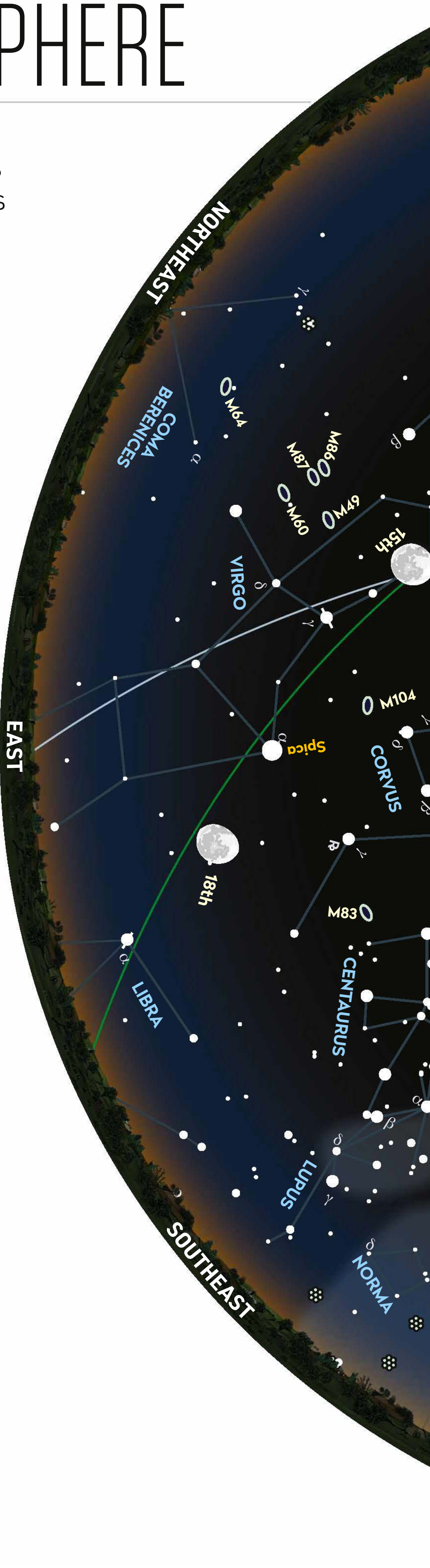
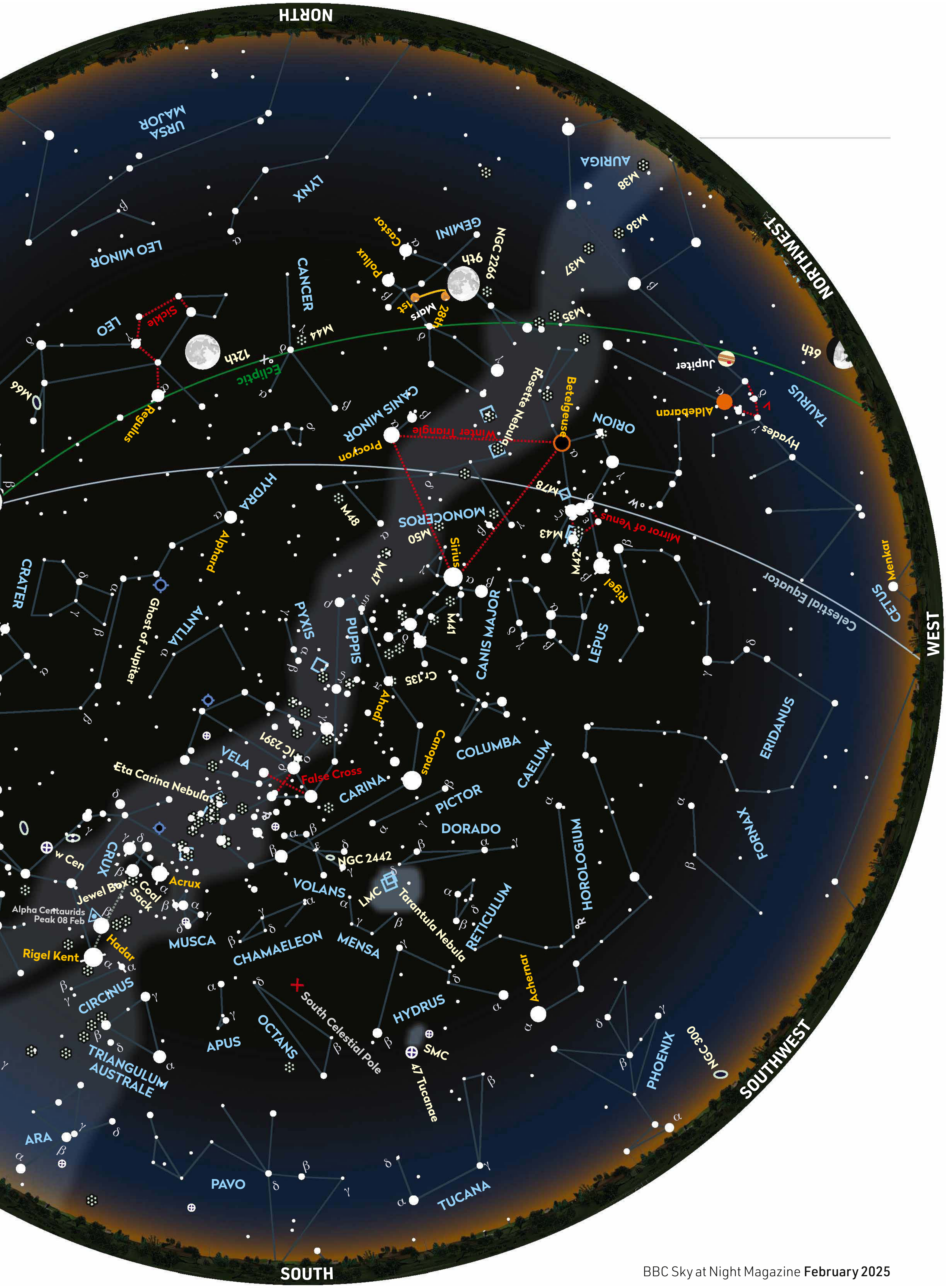


Chart key

GALAXY
OPEN CLUSTER
GLOBULAR CLUSTER
PLANETARY NEBULA
DIFFUSE NEBULOSITY
DOUBLE STAR
VARIABLE STAR
COMET TRACK
ASTEROID TRACK
METEOR RADIANT
QUASAR
PLANET

STAR BRIGHTNESS:
MAG. 0 & BRIGHTER
MAG. +1
MAG. +2
MAG. +3
MAG. +4 & FAINTER

CHART: PETE LAWRENCE


NORTH
URSA MAJOR
LYNX
AURIGA
M38
M36
M37
NORTHWEST
LEO MINOR
CANCER
GEMINI
Castor
Pollux
9th
NGC 2266
1st
Mars
28th
M35
M44
Sickle
LEO
12th
Ecliptic
M66
Regulus
Jupiter
6th
TAURUS
Aldebaran
Hyades
CANIS MINOR
Procyon
Winter Triangle
Rosette Nebula
Betelgeuse
ORION
M78
HYDRA
Alphard
M48
MONOCEROS
M50
Sirius
M43
M42
Mirror of Venus
Rigel
Celestial Equator
Menkar
CETUS
WEST
CRATER
Ghost of Jupiter
ANTLIA
PYXIS
PUPPIS
M47
M41
CANIS MAJOR
LEPUS
Cr135
Ahadi
ERIDANUS
IC 2391
VELA
False Cross
Canopus
COLUMBA
CAELUM
Eta Carina Nebula
CARINA
PICTOR
DORADO
FORNAX
HOROLOGIUM
ω Cen
CRUX
Acrux
Jewel Box
Coal Sack
Alpha Centaurids
Peak 08 Feb
NGC 2442
VOLANS
LMC
Tarantula Nebula
RETICULUM
Hadar
Rigel Kent
MUSCA
CHAMAELEON
MENSA
Achernar
CIRCINUS
South Celestial Pole
HYDRUS
APUS
OCTANS
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SMC
47 Tucanae
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